THE

HAWAIIAN

PLANTERS' RECORD

VOL. XX — JANUARY, 1919 — No. 1

A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the plantations of the Hawaiian Sugar Planters' Association

The Hawaiian Chemists' Association.

The sixteenth annual meeting of the Hawaiian Chemists' Association was held on October 28th, 29th and 30th. The reports of the committees on subjects connected with the sugar industry will appear in this and the following *Record*. The following officers were elected for the ensuing year:

President—P. S. Burgess.

Vice-President—J. P. Foster.

Secretary-Treasurer—S. S. Peck.

Executive Committee—J. W. Donald, H. F. Hadfield, H. S. Walker, Geo. F. Renton, jr., R. S. Norris, and J. A. Verret.

Suspended Solids in Mixed Juice.

The present number of the *Record* contains a description of an improved piece of apparatus for determining suspended solids in the mixed juice. From the description, this apparatus can be made in any of the factory shops, and it is hoped that it will make more general this important determination for factories that weigh their mixed juice. An accurate gravity solids and sucrose balance can not be made without this determination. It is of especial importance in determining the weight of gravity solids in the press cake.

It must be admitted that the determination is not a very satisfactory one at the best, on account of the difficulty of getting reliable samples. But it is much better to determine the amount as nearly as possible, than to ignore it and make no allowance for its presence in the mixed juice. R. S. N.

WHAT PAPER MULCHING REALLY MEANS.

By H. P. Agee.

It is manifest that a gain in sugar yield to be acceptable must more than offset the increased cost per acre incurred to bring it about. When this increased cost per acre consists in expenditures for materials, such as fertilizer, etc., there is less question about its advisability than when an increased use of man power is involved, as this may draw labor from other equally important operations. We frequently forego an evident gain in sugar because the labor situation precludes a certain practice one would put into effect. In fact, it has become a common saying, both here and in other sugar countries, that on a plantation it is not what you ought to do, or want to do, but what you *can do under the circumstances* .

Now, most of these circumstances might be summarized in the form of three cardinal points bearing on sugar production:

C. Cost of production per acre.
Y. Yield of sugar per acre.
L. The labor situation.

One of these factors may be bettered at the expense of appropriate sacrifices of one or both of the others, as any one handling cane lands knows from his daily experiences.

For example, we increase the expenditure of fertilizers, thus bettering Y at the expense of C. We irrigate, drawing upon C and L for the sake of Y. We weed a field, bettering Y again at the sacrifice of C and L.

We omit a weeding through lack of labor, knowing that it will cost more per acre a month later, hence bettering L to the detriment of C and Y. A field is thrown out; Y suffers, but the benefits at C and L are thought to compensate. And so it goes, good management consisting partly or largely of sound judgment in seeing that the gains more than make up for the sacrifices.

Few plantation operations benefit more than one of these factors at a time. An improvement in yield usually draws both upon the labor situation and the cost per acre. To improve the labor status and the yield simultaneously is a rare opportunity even at a considerable increase in the cost per acre. To bring such a thing about with but little adverse effect on the cost per acre would mean that we have increased the production, lowered the cost of production per ton, and, through a relief of the labor

situation, increased the area that can be cared for in a first-class manner.

Yet is this not what paper mulching does under conditions to which it is suited?

Paper mulching it appears will increase the yield per acre because it will prevent delays, very costly delays, in getting a new crop under way and growing. Paper mulching will increase the good results of fertilizers. It will prevent the excessive leaching of soluble nitrates in rainy districts. It will provide a zone where the moisture content of the soil is more nearly optimum and will help the cane in this way. It will save the fertilizers from being used by weeds, for it will suppress weeds better than hoeing or cultivating. Also, it prevents the cane in a measure from acting as a weed against itself. At a certain stage of the growth of young cane there are invariably more shoots than we find sticks at harvest. We have normal conditions with 25,000 sticks per acre, three per running foot of row at harvest time. At the age of five months there are perhaps 50,000 shoots per acre. All of these have been fed on costly fertilizers, but half of them die out after handicapping the growth of the other half. With row mulching this excessive stooling out of the cane plant is reduced in an appreciable way. The shoots that do come grow faster, there being less of a struggle with their fellows.

Paper mulching does not actually decrease the cost per acre, but it substitutes material for labor, relieving the labor situation by eliminating or greatly reducing the most tedious and expensive weeding, that within the cane line itself, where the operation ceases to be hoeing and becomes *hand* work, literally.

To summarize, paper mulching will increase the yield per acre, decrease the cost per ton, and reduce the labor required for caretaking operations.

Any one of these is an important consideration; combine them and they play upon each other and multiply in a way that is surprising once the situation is analyzed and fully understood.

At the Olaa Sugar Co. the proposition has been worked out in an experimental way to their entire satisfaction, and the paper plant now being erected there bears ample testimony to their faith in the practicability of mulching.

To what extent can this practice be employed to such manifest advantage outside the Puna district? Thus far the only other experiments that have been harvested are those conducted cooperatively between the Station and the Hilo Sugar Co. It is more particularly with a discussion of the results obtained there that we proceed.

When, in 1916, we secured the permission of Mr. C. F. Eckart

to conduct these paper mulching tests, it was with the idea of testing the principle involved, and considering the imperfections of the methods employed by us at that time over the improved practice finally worked out in the Olaa investigations, the results might have been far less favorable without proving disappointing. The only asphalt-felt obtainable in the Islands for the work at the time the experiments were started was a heavy grade material weighing 10.5 pounds per square. Bought at retail in Hilo under war conditions, for the sake of expediency, and with the knowledge at the time that much cheaper paper could be bought or manufactured for practical use, the price per acre paid for mulching paper used in these experiments will not, we hope, be confused by anyone with the cost figures which really pertain to paper mulching as a coming agricultural practice. At Olaa a much lighter felt paper, weighing not over 9 pounds per square, had already been shown to be preferable, but there was none of this on the market at the time. Row-mulching as a process was still awaiting development, and various steps which have since been made a part of the improved practice were lacking in the procedure followed at Wainaku. It is reasonable to presume that an improvement of method might have resulted in better yields; the amount of labor saved, however, tallies very well, Mr. Eckart tells us, with his experience at Olaa. He states that in a series of row-mulching tests with short ratoons harvested in 1918 they obtained a gain of 25 per cent in the yield of sugar with 55 per cent less caretaking labor as compared with the unmulched plots.

The tests at Hilo Sugar Co. reported by Mr. Verret dealt with both row-mulching and kuakua mulching, but as the row-mulching, a later development, has so many points of superiority over kuakua mulching, from a practical standpoint we need only concern ourselves with that part of the test dealing with the better practice.

These results follow:

Treatment	No. of Plots	Plots	Yield per Acre	
			Cane	Sugar
Paper—Fert. in December between cane rows	3	A	47.39	6.32
Paper—Fert. in October over stools before placing paper	3	B	44.28	5.90
No paper—Fert. same as A plots	6	X	44.35	5.76

The A and B plots were mulched, the X plots were not. The A and X plots received the fertilizer at the same time, two

months after placing the paper. The B plots received the fertilizer before placing the paper, but unfortunately the paper was not slit according to what has since been found the best method at Olaa, and we are inclined to accept the A results as more nearly representative of improved practice or at least more comparable with the check plots X, especially as the B plots introduce a variable in the time of applying the fertilizer.

If we take the A plots against the X we have a gain of 0.56 ton of sugar in favor of paper, or if one chooses to average the A and B plots against the checks, the gain is 0.35 ton of sugar.

The costs per acre in this experiment were approximately as follows. These figures are from our notes, with certain amplifications by the Hilo Sugar Co.

A AND B PLOTS.	Cost per Acre.
Oct. 12, 1916—Palipali and laying paper	$ 6.00
Dec. 16, 1916—Hoeing and spray	4.16
Apr. 20, 1917—Hoeing, slight	2.00
July 18, 1917—Stripping and cleaning	4.40
Cost of operations	$16.56
Cost of paper	66.00

X PLOTS.	Cost per Acre.
Oct. 12, 1916—Palipali	$ 5.58
Oct. 14, 1916—Offbarring	4.72
Nov. 22, 1916—Hoeing	3.44
Jan. 15, 1917—Horner harrow	1.20
Jan. 31, 1917—Hoeing	3.50
Apr. 20, 1917—Hoeing	10.32
July 18, 1917—Stripping and cleaning, etc.	7.32
	$36.08

We would again call attention to the fact that $66 per acre for paper is an exhorbitant and abnormal price. We have shown these results and cost figures to Mr. C. F. Eckart, asking him to furnish us with practical cost figures for mulching paper. He has done this and has furthermore supplied us with an interpretation of the results which sets a tangible value on the most important benefit derived from paper mulching—that of replacing hand labor with the use of a purchased material or a manufactured by-product. We feel that it is only through a careful study of the situation along these lines that one can fully appreciate what paper mulching really means.

To quote Mr. Eckart:

"Since the row-mulching process was devised primarily to reduce the labor requirements in the caretaking of cane fields and therefore increase the productive value of the field labor engaged, it naturally follows that the main point to determine in these experiments is the extent to which this was accomplished.

"Mr. Verret's figures show that, omitting the bonus payments

and the cost of fertilizer, the cost of bringing the cane to maturity in the ordinary field practice was $36.08. The cost of the manual labor required was approximately $33.12. Allowing $1 per day per man, we then have 33.12 man-days per acre as representing the caretaking labor which was required to produce 5.76 tons of sugar. As against this we find on the row-mulched area 16.56 man-days producing 6.32 tons of sugar. The outstanding point of greatest importance is, then, that 9.72 per cent more sugar was grown with practically 50 per cent less caretaking labor on the mulched area than on the unmulched area.

"In the following calculations I have endeavored to make clear the real significance of the practice and to show particularly what the substitution of material for labor means during periods of labor shortage. In order to do this I have been obliged to assume a number of figures, and while these may not be closely applicable to Wainaku conditions, they will not be so far off as to invalidate in any way the general comparisons.

"I have assumed, for instance, that in the ordinary practice 60 per cent of the total field and factory labor is engaged in the caretaking of the fields and 40 per cent in harvesting and manufacture. Likewise, I have allowed $7.50 per ton sugar for manufacture, $1.50 per ton cane for harvesting and transportation, $60 per acre for fertilizer, $3 per acre for applying fertilizer, and $25 per ton sugar for total marketing costs and differential. These high costs for manufacture and harvesting include a bonus of 50% on the manual labor involved, and this same bonus rate is employed throughout the calculations whenever applicable. I have also assumed $33 per acre as a fair charge for the cost of paper of 36″ width; suitable asphalt-felt made from bagasse can no doubt be made for less than this figure.

"Under conditions of ample labor supply the following comparisons may be made:

COMPARISON OF PRACTICES UNDER CONDITIONS OF AMPLE LABOR THROUGHOUT THE ENTIRE CROP PERIOD.

	Row-Mulching	Ordinary Practice
Man-days in caretaking work	18.56	35.12
Man-days, harvesting and manufacturing	23.30	22.08
Total labor: caretaking, harvesting and manufacturing	41.86	57.20
Acres taken care of	1.00	1.00
Cane produced, tons	47.39	44.35
Sugar produced and manufactured	6.32	5.76
Caretaking costs (incl. bonus)	$ 27.84	$ 55.64
Fertilizer	60.00	60.00
Harvesting	71.09	66.53
Manufacture	47.40	43.20
Marketing and differential	158.00	144.00
Bagasse paper	33.00	....
	$397.33	$369.37
Proceeds with sugar at 6c	$758.40	$691.20
Cost of production, disregarding overhead expense	397.33	369.37
	$361.07	$321.83

"The difference in favor of the row-mulched area is therefore the direct gain of $39.24 per acre *which was obtained with* 16.56 *days less labor than was required on the unmulched area.* This latter point is of the greatest importance and represents the primary object towards which the row-mulching process is directed.

"If the unmulched area were to suffer a reduction of 16.56 days labor per acre, or 26.82 per cent of the total man-days required for the combined operations of caretaking, harvesting, and manufacturing, with no diminution in area or applied fertilizer, it is safe to assume that the yields would fall off to *at least* a proportional extent and instead of obtaining 44.35 tons cane per acre or 5.76 tons sugar, we would not obtain more than 32.46 tons of cane or 4.22 tons sugar. Under such conditions the comparative figures would be as follows:

COMPARISON OF PRACTICES UNDER CONDITIONS OF ACUTE LABOR SHORTAGE (26.82% REDUCTION).

	Row-Mulching	Ordinary Practice
Man-days in caretaking work	18.56	25.12
Man-days, harvesting and manufacturing	23.30	16.74
Total labor in field and mill	41.86	41.86
Acres taken care of	1.00	1.00
Cane produced, tons	47.39	32.46
Sugar produced and manufactured, tons	6.32	4.22
Caretaking costs	$ 27.84	$ 40.72
Fertilizer	60.00	60.00
Harvesting	71.09	48.69
Manufacture	47.40	31.65
Marketing and differential	158.00	105.50
Bagasse paper	33.00	....
	$397.33	$286.56
Proceeds with sugar at 6c	$758.40	$506.40
Cost of production, disregarding overhead expenses	397.33	286.50
Gain	$361.07	$219.84
Extra gain per acre due to row-mulching	$141.23	

"In a similar way and by making the same general assumptions it may be shown that with a 10 per cent labor shortage the gain per acre from row-mulching, where the entire area is treated in accordance with this practice, works out to $76.37, and with a 20 per cent shortage it is $114.65.

"On the basis of these rough calculations a shortage of labor amounting to 10 per cent can be entirely relieved by mulching 37 per cent of the crop area; a 20 per cent shortage can be relieved by mulching 74 per cent of the crop area. *In each case the total gain (direct and indirect) per acre mulched is practically* $141 *for the set of conditions under consideration and similarly for all other shortages up to the point when the labor conditions are relieved.*

"In the above calculations I have assumed that the cost of harvesting and manufacture increased proportionally with the yields. Of course, this is not really the case. These and similar small considerations have been disregarded in these rough calculations, which are intended merely to show the real significance of row-mulching.

"On looking over the quality ratios for cane as reported for the Wainaku tests I notice that the juice of the row-mulched cane was better than that of the unmulched cane. This confirms

our experience at Olaa, where the difference in favor of the mulched cane seemed to be too large and consistent to appear accidental.

"In the Olaa tests the juice of the row-mulched cane stood 15.3% sucrose and 87.1 purity as against 14.6% sucrose and 85.9 purity in the case of unmulched cane; these figures represent the average of 10 repetitions.

"In the actual process of row-mulching it has been found to be a far more effective procedure to apply a fairly heavy dressing of soluble fertilizer before laying the paper than to make the first application of fertilizer after the paper is laid. In the process as now developed the paper is slit along the tent-like elevations about four weeks after it is laid with a pronounced increased efficiency of the applied fertilizer. We have also demonstrated to our satisfaction that row-mulching is distinctly more profitable than kuakua mulching.

"I have noticed that almost invariably the first question asked, in discussions concerning the economy of row-mulching, has to do with the cost of the paper. While, of course, it is to be desired that the cheapest suitable material be obtained for the practice, it is made clear, I think, in the preceding calculations, that in the face of a labor shortage the question of paper costs need hardly arise as a deterrent consideration. With our limited labor supply it is manifestly not proper to merely consider the intrinsic wage cost of labor along with fertilizer and paper costs, etc. Labor and material cannot be compared or viewed together in this way. The labor is basic—it applies the material and is the essentially limiting factor in production, so far as cultural agencies are concerned, materials being always procurable except in extremely rare emergencies.

"On account of the broad application of the process and the large number of men which can be replaced by mulching-felt on the plantations of wet districts, I am convinced that paper for this particular agricultural use will in time be employed and relied upon as one of our most effective labor-saving devices. The Olaa Sugar Company is already making preparations to adopt the process as a routine practical measure. Under the most favorable conditions there are always periods when we are short of labor, and with the present unfavorable outlook in this regard I feel that too much importance cannot be attached to efficient labor-saving measures.

"Considerable emphasis should be laid on the fact that many grades of paper and paper-felt are entirely unsuited for row-mulching. Generally speaking, the paper must be strong enough to sufficiently resist the beating action of heavy rains but not so

tough as to preclude a fairly uniform stand of cane in the row. Of the many papers tried out at Olaa the best results were obtained with a soft, pliable asphalt-felt weighing a little less than 9 lbs. per 100 sq. ft., and which had a bursting strength (Ashcroft test) of 26.6 lbs. per square inch when dry and 18.1 lbs. per square inch after immersion in water for 10 minutes.

"While this paper gave very satisfactory results, it should be pointed out that it was simply the best material, manufactured for another purpose, which we were able to procure and adapt to our requirements. There can be no doubt that a paper made for the specific object of row-mulching would show some improvement over it. Possibly a saturated asphalt-felt with a bursting strength of 20 lbs. per sq. in. when dry and 15 lbs. per sq. in. when wet would be better.

"At the present time we are trying out different widths of mulching felt and it is already apparent that much narrower strips than that employed in the Hilo Sugar Company tests will be found more economical, thus materially reducing the acre costs for paper. We are also planning tests dealing with different weights and thicknesses of paper, and it is not too much to expect that eventually the cost of the paper used per acre will not amount to more than the wage cost of the labor which it displaces."

As a final consideration of paper mulching, there is a point that deserves emphasis. Let us picture a typical case of a plantation in the rainy district which in the latter part of the grinding season is compelled to close down the mill for the sake of turning the harvesting gangs into the fields of young cane to hoe out the weeds. Before this is resorted to the weeds are usually well ahead. Every day counts in getting the crop off; the juices are steadily becoming poorer. Over a wide area of young cane, the weeds have been consuming soluble nitrogen that we import for the cane at from $4 to $10 per unit. Perhaps fertilization has been delayed until the fields can be weeded. Here there is a loss in time which is equally as important. The weeds furthermore have checked the cane appreciably. There are some fields that are badly neglected for a time at least, and this tells ultimately in the yields.

Labor may have been sufficient early in the grinding season, or it may have been a little scarce. At any rate, as the season advances, the area of young cane to be cared for increases day by day and the demand for labor becomes greater and greater until we have, as the grinding proceeds, what Mr. Horace Johnson describes as a peak load in the labor situation, requiring "more labor to keep all operations going than is available, and it

would not be practicable to keep sufficient labor on hand for this peak load even if the labor were available." He feels that "paper mulching would do much toward leveling this peak load and its value would be great. If paper mulching will pay its own expenses it would pay good dividends on this release of labor."

Mr. Eckart has shown in his estimates how a 10 per cent labor shortage is corrected by having 37 per cent of the crop area under paper; a 20 per cent shortage, by mulching 74 per cent of the crop area. But Mr. Johnson has in mind, we take it, that there is an increasing detriment to a plantation through lack of labor as the grinding season advances, affecting both the crop that is being harvested and the young crop that has started growing. One is deteriorating in quality, the other is being stunted by weeds. There is a further drain in that each day's delay harvesting throws the start of the new ratoon fields a day further beyond the summer growing season.

So there are many angles of advantage to row mulching. The solution of the weeding problem—for it is nothing short of this—presents many promising phases, and it is unlikely that we have anticipated all of them.

FIGHTING INSECTS WITH POISON GAS.

When Mr. John T. Moir suggested at the annual meeting that the German poison gas warfare be employed against leafhoppers, the proposition was viewed lightly by many, though Mr. Moir insisted that it deserved serious attention, and now we must accede as much if we credit a recent issue of the New Orleans Times-Picayune, which reads:

Utilization of powerful gas used by the American army in Europe for the purpose of ridding the South of the cotton boll weevil and other insect pests that destroy crops, and thus turn a wartime discovery into a commercial benefit, is receiving the attention of representatives of the federal government.

With that end in view, agents of the government are now in the Southern States for the purpose of conducting a series of experiments to determine if a new and powerful gas that was recently discovered can be used in destroying boll weevils, boll worms, caterpillars and insects of similar nature that destroy millions of dollars' worth of farm products every year.

The new powerful gas is a by-product of Southern pine and is made from pine stumps. When its value in warfare was definitely established

a large plant was built in Florida for the manufacture of the gas. The plant has a capacity for turning out large quantities of the product, and if the experiments in the way of destroying insects prove to be successful, it is planned to continue the making of the gas for commercial purposes.

The discovery and use of the gas was a war-time secret, because the government did not want the Germans to know what was being done along that line. The end of the war has opened the door for experiments in another direction.

The new experiments, it is understood, will be under the joint supervision of the Department of Agriculture and of the War Department.

We have addressed the Department of Agriculture in the matter, asking for further information in the premises and suggesting the local field as an apt one for experimental trials.

H. P. A.

HIGH YIELDS FROM LAHAINA CANE.

In the October number we published results of a variety experiment from the upper lands of the Oahu Sugar Co., showing results whereby Lahaina cane was outyielded by H 146 and another variety on the upper lands of the Oahu Sugar Co. We referred in the article to earlier experiments with about the same results.

Mr. E. K. Bull contends, and we agree with him, that the Lahaina variety should be given more credit than the published results of this experiment indicate, and we now take pleasure in presenting certain data not heretofore available which he has given us from his surrounding fields. Mr. Bull, in referring to the *Record* article, says:

"According to the Summary of Results from Experiment No. 11, the Lahaina variety gave a yield of 47.05 tons of cane per acre, and 6.03 tons sugar per acre, as against 73.10 tons cane and 9.25 tons sugar per acre for the H 146 variety, or 26.05 tons cane and 3.22 tons sugar less per acre than H 146. As you may note from the enclosed statement, the yield of Field No. 49, 102.33 acres of Lahaina cane, harvested practically at the same time as the experiment plat, was 73.46 tons cane per acre, and 10.19 tons sugar per acre, or 4.16 tons sugar per acre more than the Lahaina variety produced in the experiment, and 0.94 ton more sugar per acre than H 146. An area of 7.5 acres of the H 109 variety, grown alongside the Lahaina cane, was during 1917 so badly attacked by leafhopper and eye-spot disease that the greater part of the cane either died out or had to be destroyed; the yield from this area, which is shown separately, was only 24.80 tons cane per acre, and 2.21 tons

sugar per acre. The quality of the soil in the experiment plat is the same as in Field No. 49, of which the experimental area is a part, and the 102.33 acres of Lahaina cane received identically the same treatment as the experimental area. The question, therefore, again arises: 'Why does the Lahaina cane invariably give such a poor yield in the variety tests?' and 'How can the result of the experiments be reconciled with the statements of the yield of Lahaina cane grown on larger areas in the same locality and under the same conditions?'

"In the comment on the result of variety experiments Nos. 11 and 13, the following remark appears in the October *Record*:

"'It should be stated that the Lahaina in these experiments was attacked by eye-spot disease and leafhoppers, and damaged to quite an appreciable extent. The H 146 and Badila adjoining the Lahaina did not suffer from these attacks, as they were not touched by the eye-spot disease and the growth did not appear to be checked by the leafhoppers at any time.'

"From this remark one would naturally draw the conclusion that the Lahaina cane is particularly susceptible to attacks of eye-spot disease and leafhopper, but the yields obtained from the bulk of our fields of Lahaina cane do not support any such contention: of a total of 4217 acres of Lahaina cane (plant and long ratoons) harvested during the past season, 2071 acres gave an average yield of over 10 tons of sugar per acre, and these fields included sixth, seventh, and even ninth ratoons, grown at an elevation of 300 to 600 feet. Considering these facts, how is the exceptionally low yield of Lahaina, grown in competition with the other varieties in the experiments, to be accounted for?"

We might account for the lower yield of Lahaina cane on these plots by saying that in places the variety is beginning to give way on the new lands in somewhat the same way it has on many of the older fields of this island, and that the experiments were unhappily located in bad spots. At Ewa plantation, H 146 developed the symptoms we have associated with the so-called Lahaina disease and was discarded there on that account. It was, however, somewhat more resistant. At Waipio, H 146 has never played out to the degree that Lahaina has, but its growth there is not excellent.

In examining the experimental plats in Field 45, we observe at this time no pronounced symptoms of an unhealthy condition. In Field 49, however, some of the Lahaina plats are distinctly *off*, as are some larger patches in the surrounding field. H 146, too, has succumbed in spots, though generally it is much stronger than Lahaina. In examining the roots of some H 146 which has given way in an area where Lahaina failed and was grubbed out, we find nematode galls—a great many of them. We do not find them on the poor Lahaina, but here the roots are badly rotted and beyond the stage for an accurate examination.

H. P. A.

A PRACTICAL METHOD OF COMPARING THE RESULTS OBTAINED WHEN BURNING BAGASSE AS FUEL.*

By Horace Johnson.

Much has been written in regard to the facts of the combustion of bagasse under boilers. Every paper upon "Fire-room Efficiency" which has been read before this Association has dwelt upon the advantages of having a low moisture content in the bagasse, a high temperature in the furnace, and a low temperature of the flue gases.

That, in order to obtain these desired temperatures, the combustion chamber must be large enough to allow the process of combustion to be completed before the hot gases reach the heating surface of the boiler, and the boilers must have sufficient effective heating surface for the amount of bagasse burned.

That the percent CO_2 in the flue gases should be kept as high as possible and still avoid the presence of carbon monoxide.

We have been told time and again that in order to obtain the highest efficiency, the boiler settings must be kept tight and well insulated, to prevent the losses due to air leaks and to radiation. That the proper way to control the admission of air to the furnaces is by the regulation of the flue dampers and not by the ash-pit doors.

Suitable instruments have been described whereby we may determine the amount of draft in the furnace and at the damper and the temperature of the gases at these places. We have means at hand for obtaining the percentage of carbon dioxide, carbon monoxide and oxygen in the flue gases.

The aim in the use of such instruments is to obtain data which, when properly interpreted, will enable one to operate the boilers so as to reach the maximum evaporation of water per pound of bagasse.

During the past few years there has been a notable increase in the use of these instruments in the factories of the Hawaiian Islands, and doubtless much benefit has been derived. In many cases, however, there is a lack of proper interpretation of results or the data obtained are not brought together in a logical manner.

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* Presented at the 16th Annual Meeting of the Hawaiian Chemists' Association, Oct. 29, 1918.

To determine the actual work done by a boiler requires an elaborate test which demands the knowledge of the weight of water evaporated and the weight of bagasse burned. While the boiler feed water may be measured or weighed without unreasonable expenditure, the weighing of the bagasse is a problem not easily solved. Its bulky nature and the manner of feeding it to the boilers, makes the cost of weighing prohibitive. Even if suitable arrangements are made for obtaining the weighed quantity for the duration of the test, obtaining the skilled observers required to record the necessary weights, temperatures, pressures, etc., is another obstacle to overcome.

As a rule an operating engineer has no time nor facilities to make an accurate boiler test. If he does make one and finds low efficiency, and makes changes in his furnace or in the operation of his boilers, other tests are required in order to determine whether an improvement has been effected. The labor involved generally puts a stop to such work.

The writer presents for your consideration a practical method of comparing the results obtained when burning bagasse of different moisture content. This requires only the determination of the percent of CO_2 and the temperature of the flue gases leaving the boiler.

The accompanying charts are made to cover a range in moisture content of bagasse from 35% to 50% and flue gases having a temperature of 500° F. to 700° F. The percentage of CO_2 ranges from 6% to 16%. For the corresponding values of these variables are given the pounds water evaporated from 212° F. to steam of 125 pounds gauge pressure.

All losses of heat due to associated and combined water, excess air, etc., are taken into account and 5% of the total heat is allowed for radiation losses. The basis of the calculations is on the assumption that a pound of dry bagasse has a thermal value of 8100 B.T.U. and contains 48.0% carbon and 5.7% hydrogen.

The use of these charts may be illustrated by the following example:

Moisture in bagasse	40.0%
Temperature of flue gas.....................	500° F.
CO_2 in flue gas............................	7.0%

On chart 500 the perpendicular line from 40% moisture intersects the 7.0% CO_2 line on the horizontal representing 2.72 lbs. water. One pound of trash under these conditions is evaporating 2.72 lbs. of water from 212° F. to steam of 125 pounds gauge pressure.

Assume that operating conditions are changed with the aim

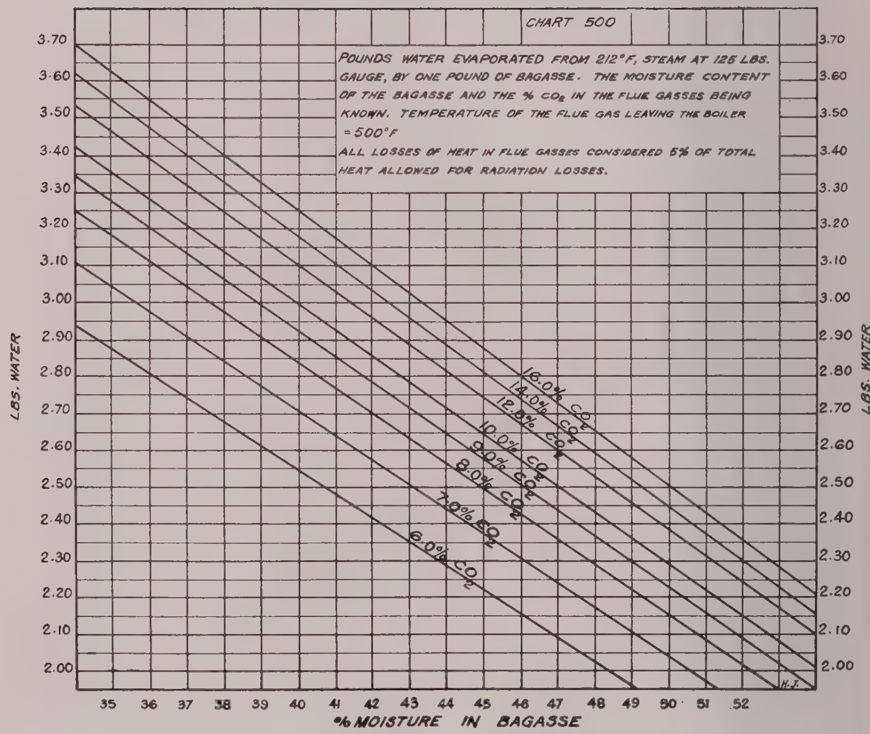
CHART 500
POUNDS WATER EVAPORATED FROM 212°F, STEAM AT 125 LBS. GAUGE, BY ONE POUND OF BAGASSE. THE MOISTURE CONTENT OF THE BAGASSE AND THE % CO2 IN THE FLUE GASSES BEING KNOWN. TEMPERATURE OF THE FLUE GAS LEAVING THE BOILER = 500°F
ALL LOSSES OF HEAT IN FLUE GASSES CONSIDERED 5% OF TOTAL HEAT ALLOWED FOR RADIATION LOSSES.
16.0% CO2
14.0% CO2
12.0% CO2
10.0% CO2
9.0% CO2
8.0% CO2
7.0% CO2
6.0% CO2
LBS. WATER
3.70
3.60
3.50
3.40
3.30
3.20
3.10
3.00
2.90
2.80
2.70
2.60
2.50
2.40
2.30
2.20
2.10
2.00
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
% MOISTURE IN BAGASSE
H.J.

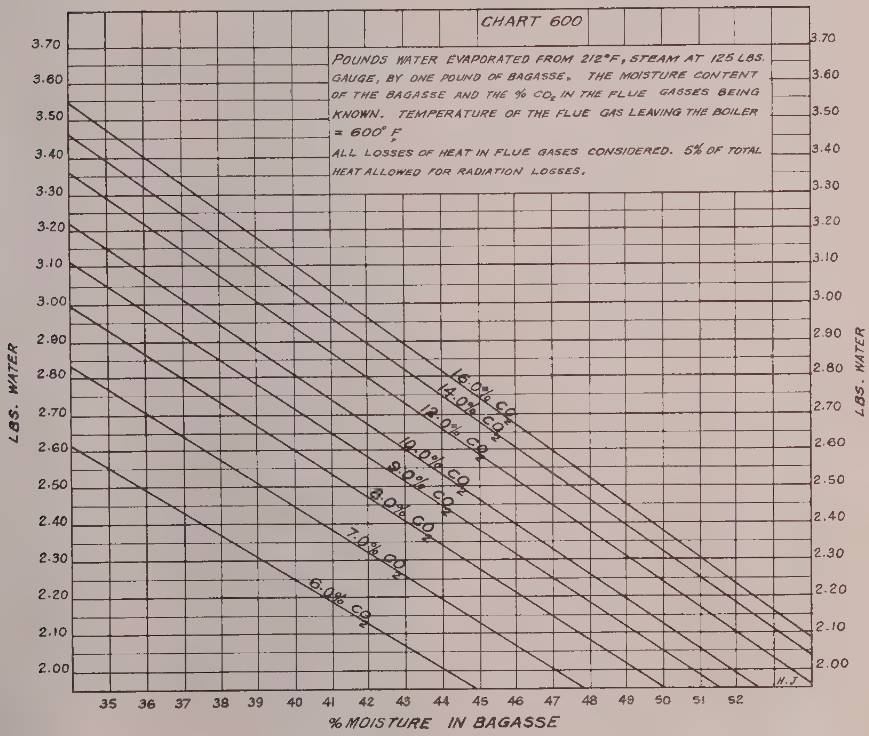
CHART 600
POUNDS WATER EVAPORATED FROM 212°F, STEAM AT 125 LBS. GAUGE, BY ONE POUND OF BAGASSE. THE MOISTURE CONTENT OF THE BAGASSE AND THE % CO_2 IN THE FLUE GASSES BEING KNOWN. TEMPERATURE OF THE FLUE GAS LEAVING THE BOILER = 600° F.
ALL LOSSES OF HEAT IN FLUE GASES CONSIDERED. 5% OF TOTAL HEAT ALLOWED FOR RADIATION LOSSES.
16.0% CO_2
14.0% CO_2
12.0% CO_2
10.0% CO_2
9.0% CO_2
8.0% CO_2
7.0% CO_2
6.0% CO_2
LBS. WATER
3.70
3.60
3.50
3.40
3.30
3.20
3.10
3.00
2.90
2.80
2.70
2.60
2.50
2.40
2.30
2.20
2.10
2.00
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
% MOISTURE IN BAGASSE
H.J.

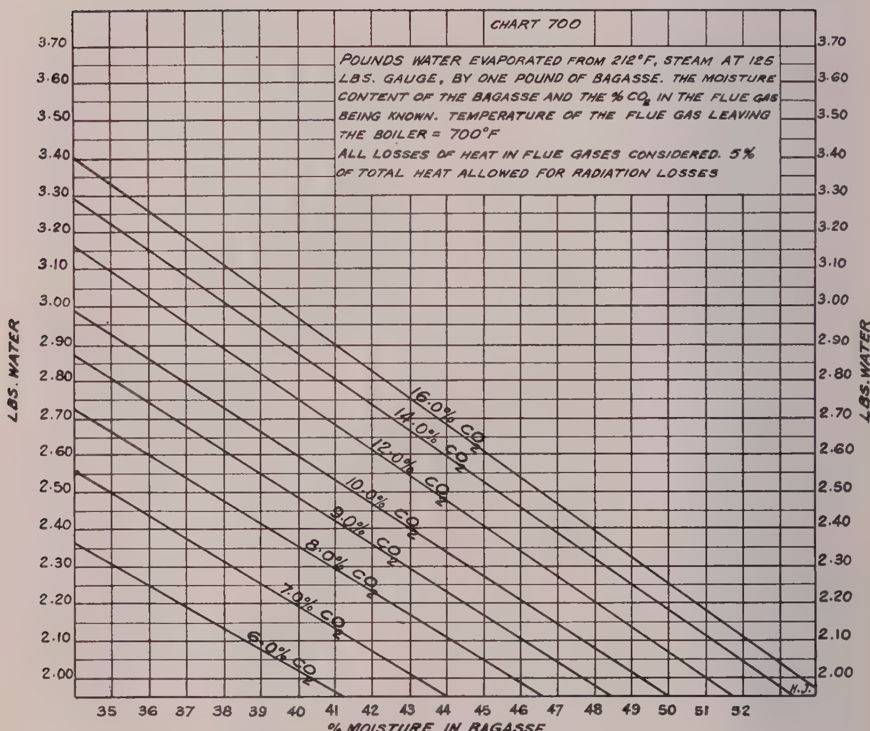
CHART 700
POUNDS WATER EVAPORATED FROM 212°F, STEAM AT 125 LBS. GAUGE, BY ONE POUND OF BAGASSE. THE MOISTURE CONTENT OF THE BAGASSE AND THE % CO_2 IN THE FLUE GAS BEING KNOWN. TEMPERATURE OF THE FLUE GAS LEAVING THE BOILER = 700°F
ALL LOSSES OF HEAT IN FLUE GASES CONSIDERED. 5% OF TOTAL HEAT ALLOWED FOR RADIATION LOSSES
LBS. WATER
3.70
3.60
3.50
3.40
3.30
3.20
3.10
3.00
2.90
2.80
2.70
2.60
2.50
2.40
2.30
2.20
2.10
2.00
16.0% CO_2
14.0% CO_2
12.0% CO_2
10.0% CO_2
9.0% CO_2
8.0% CO_2
7.0% CO_2
6.0% CO_2
H.J.
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
% MOISTURE IN BAGASSE

of reducing the excess air. The analysis of the flue gases then indicates 12.0% CO_2 and a temperature of 600° F.

Chart 600 shows for these conditions that 2.94 lbs. water are now evaporated per pound of bagasse. A gain of 8.0% in spite of an increase in the temperature of the flue gases.

It is necessary to properly interpret the results in order that the correct changes may be made to attain higher efficiency.

Assume that 12% CO_2 is found in the flue gas, no CO being present, and the temperature of the flue gas is 700° F. when burning bagasse containing 40% moisture. The combustion is good, but the temperature of the flue gas is too high. What would this indicate?

A correct interpretation would be that the heating surface of the boiler was dirty or that the heating surface was too small in proportion to the amount of bagasse burned, or possibly due to poor arrangement of baffles.

The first can be remedied by inspection and cleaning the boilers; the second condition can be improved by closing down on the flue damper, thus reducing the amount of trash burned.

Assume that the latter is done, and that the analysis then shows 12% CO_2 and the temperature of the flue gas to be 600° F.

With 12% CO_2 and 700° F. gas, the water evaporated would be 2.75 lbs. per pound of bagasse. With 12% CO_2 and 600° F. gas, the water evaporated would be 2.94 lbs. per pound of bagasse.

It must be remembered that the samples of the flue gas for the CO_2 determinations and for temperature must be taken immediately after the gases leave the boiler. The readings should be made at least every half hour for a period of several hours, in order to arrive at a correct average. If the analysis shows over 12% CO_2, the sample should be carefully analyzed for the presence of CO. While it is possible to obtain 14 CO_2 or over without CO being present, as a general rule 14% CO_2 may be considered as a practical limit.

If the percentage of CO_2 is from 12 to 14 and the flue gas temperature from 500° to 600° F., one may be assured that he is burning the bagasse with a high degree of efficiency, and if there is a lack of steam for factory purposes it is not due to poor work at the boilers, but to abnormal demands and uneconomical consumption of steam in the factory.

The writer believes that with the aid of these charts, together with the earnest endeavors of the entire mill staff, the steaming difficulties now encountered at many factories can be located and eliminated to a considerable extent.

It is hoped that those who are directly connected with the operation of the sugar factories will find this method of comparing results to be of practical value and an incentive to further study the operating conditions of their fire rooms.

ECONOMIC METHOD OF FERTILIZER APPLICATION.*

By S. S. Peck.

As related to the sugar-cane industry, there are two methods in the application of fertilizers to the cane, distributed to the cane by hand, or dissolved in the irrigation water. The last is naturally applicable only to readily soluble fertilizer materials; the first is essential particularly in the case of materials which must be covered to produce the best results.

Nitrate of soda, sulfate of ammonia, superphosphate of lime, and sulfate of potash are the materials which are soluble in water. Bone, blood, tankage, fish scrap, reverted phosphate, are not soluble. These in order to be effective must be covered with soil in order to either produce their decomposition or bring their particles nearer the feeding roots of the crop.

TEMPTATION TO WASTE.

A complete fertilizer consists generally of bone or superphosphate, sulfate of ammonia, nitrate of soda, blood or tankage or fish scrap, and sulfate of potash. These in varying proportions, to suit the peculiar need of the soil, are applied at the rate of 1000 pounds per acre, generally in two applications. The first application is made along in September or October of the first year of the plant, when the cane is about two or three feet high, usually after an irrigation, and followed by a light hoeing in order to get the fertilizer under the ground. The second application is made about March of the following year. Sometimes after a warm winter or when the first season's growth has been favorable, the cane may be four to six feet high and already lodging. In this case fertilizer application is not only a difficult operation, but it presents strong temptations to the wily worker to dump his quota in an uneven manner, and a considerable

* Presented at the 16th Annual Meeting of the Hawaiian Chemists' Association, Oct. 28, 1918.

portion thereof on the leaves of the cane instead of on the ground. Then unless a fortunate rain follows, a large percentage of the fertilizer is a loss, at least to that crop.

In the late spring or early summer extra dressings of nitrate of soda are given the crop. Where irrigation is practiced, this is usually done in the irrigation water; in this way a considerable saving in labor is effected. Moreover, the application is generally 300 pounds per acre, and in some cases this may be divided into three doses. It is readily conceivable that the distribution of 100 pounds of this material over an acre of land cannot be done in a very even fashion by hand.

In order to get the full benefit from fertilizers they must be evenly distributed in the soil. Lipman and Brown in a series of experiments on ammonia and nitrate formation in soils, quoted in the *Record*, Vol. IV, page. 149, showed this necessity. In order to get full benefit from organic fertilizers, they must be covered with at least a half inch of soil; applications of such material should therefore be followed by work with the hoe, or other light cultivation. This is easy on the first application, but seldom on the second. Application by hand can be done in the first instance at about the rate of 10 bags of fertilizer per day's labor and in the second at about 8 bags. Application of nitrate in water is done at about the rate of 20 bags per day's labor.

Soluble phosphoric acid is readily and rapidly fixed by the soil; it would not be advisable to apply it in water. Sulfate of potash is less readily fixed; it might be possible to apply it in water. Sulfate of ammonia is absorbed from solution when passing through a column of soil, but it has been found that it is not taken out of water running over the soil to any appreciable extent, and nitrate is not fixed at all; so these two can be applied in water. All organics, not being soluble in water, cannot be handled thus, and the same is true of materials like reverted phosphate.

DESIRABLE PROCEDURE.

Phosphoric acid and potash, being fixed by the soil, are not lost to any appreciable extent in the leachings from the soil. Whatever the transformation of the added material, it is practically instantaneous. There is therefore no reason why these fertilizers should not be applied at an early stage of the growth of the cane in sufficient amount for the full crop; and there may be reasons why this is a desirable procedure. I suggest the following not as typical of all conditions, but as possible under

particular conditions, and by suitable modification, applicable to all cases where irrigation is practised.

I take, simply for ease of illustration, the case of a plantation using a fertilizer of the following formula at the rate of 1000 pounds per acre:

6% phosphoric acid, water soluble.
9% nitrogen, half sulfate, half nitrate.
6% potash, from sulfate.

This is equivalent to a total ration of:

60 pounds of phosphoric acid;
45 pounds of nitrogen from sulfate of ammonia;
45 pounds of nitrogen from nitrate of soda; and
60 pounds of potash.

Half of these amounts would be the dose at each application.

In terms of raw material of average composition, the thousand pounds would be made up as follows:

300 lbs. superphosphate;
220 lbs. sulfate of ammonia;
290 lbs. nitrate of soda;
120 lbs. sulfate of potash;
70 lbs. filler.

This in 125-pound bags gives eight bags, four to each application. On the basis of work as given above, it would cost, at the rate of a dollar per day's labor, ninety cents per acre for the application of the fertilizer.

MIXED FERTILIZER.

Let us now put on all the phosphoric acid and potash by hand in the first application, along with the usual ration of nitrogen; and the balance of the nitrogen in the water for the second application.

The mixed fertilizer would then have a composition as follows:

Superphosphate	300 lbs.
Sulfate of ammonia	110 "
Nitrate of soda	145 "
Sulfate of potash	120 "
Total	675 "

This can be placed in five bags of 135 pounds each and applied, figuring on the rate of the first application, at a cost of forty-five cents per acre. This leaves 110 pounds of sulfate of ammonia and 145 pounds of nitrate to be placed in the water the following spring, which at the same rate as nitrate would cost 10 cents per acre. The total cost is then sixty-four cents per acre. This is not only an economy of twenty-six cents per acre in operation, but it effects two other important points:—First, it makes positive an even distribution of the expensive nitrogenous dressings, and, second, it releases a certain number of men during the harvesting of the crop, a time when every man counts. There may be objections to this, from the standpoint of the agriculturist or tha fertilizer mixer, and it will be interesting to weigh these against the advantages as presented above.

THE MANUFACTURE OF INDUSTRIAL ALCOHOL FROM MOLASSES.*

By J. P. Foster.

The operation of a distillery for the production of industrial alcohol presents few if any difficulties. The manipulation of a still, where high-grade Cologne spirits is not desired, is much more simple than the operation of a vacuum pan or of a modern multiple effect.

Such problems as are presented lie almost exclusively in the process of fermentation, and there, it is true, the problems are many and varied, but by no means impossible of solution. A distillery operated on a sugar plantation, in conjunction with the factory, will have to contend with an almost unbelievable bacterial activity.

Air and water, as well as the molasses, are contaminated with yeasts, moulds, and fungi from diseased cane in the fields, from fermenting mud-press cake, and from innumerable focii of infection in the factory. This condition can only be met by the most careful antiseptic methods, asepsis alone being out of the question. There must, of course, be pure yeast culture, and, on account of our climatic conditions, the yeast must be suitable

* Presented at the 16th Annual Meeting of the Hawaiian Chemists' Association, Oct. 28, 1918.

to high temperatures. The yeast must also ferment very rapidly so as to attain a satisfactory antenuation of the mash before the wild yeasts can get hold, and the difficulty is to obtain this rapidity of fermentation without a temperature which will render the pure culture anaemic and unfit for further fermentation. It is not possible to do so without cooling coils in the fermenting tubs, so that the temperature may be kept down to a maximum of 95° F., with 85° preferable. The correct procedure in the fermenting house is to have a suitable cooling system, to sterilize the molasses, use only condensation water from the effects for making the dilution of the molasses, to set up the fermentation with pure culture yeast, and not to fill the tubs much, if any, over half full. This latter is an important condition, for if it is observed the heavy layer of foam on the surface of the fermenting body will be undisturbed by air currents, and there will be also a thick layer of CO_2 over the foam. As a result, wild yeasts will be to a great extent prevented from gaining access to the tubs. These precautions, with a liberal use of a scrubbing brush and "elbow grease," will ensure satisfactory results in the fermentation house.

After the fermented material, or "beer," has been pumped over to the still house, the procedure is simple in the extreme.

Fortunately, the amount of labor required is small, so that it is not difficult to obtain men who are suitable to be "broken in" for the work. If one were starting a new sugar factory in the Islands, it would not be impossible to obtain almost at once a crew of men reasonably familiar with the various processes. Engine tenders, heater men, clarifier men, evaporator, pan, and centrifugal men would be plentiful. On the contrary, in starting a distillery, there is no labor here from which to draw trained men, and the men must be taught the work. This applies with greater force to cement manufacture in the Territory, because more labor is required there than in a distillery. One good pure culture man, two fermenting-house men, and two still men, five in all, are all the skilled labor required, so that the labor question is not at all serious in a distillery.

If the production of rectified spirits is required, then the problem would become much more serious.

All the problems to be overcome in an industrial distillery may be summed up in two words: "Temperature Control."

If this is satisfactory, all the other difficulties will solve themselves.

REPORT OF COMMITTEE ON EVAPORATION AND BOILING.*

By S. S. Peck.

In response to a series of questions relating to evaporation and sugar-boiling, eight replies have been received. The committee confesses that little that is new has been developed in the replies, and feels that it would be of no interest to publish them *in extenso*. Rather, the novel features that exist have been selected and are herewith presented.

Cleaning Evaporators. Mr. Alston describes the following method introduced at Wailuku by Mr. Bento. The cells are filled with water to just cover the top tube sheet. Approximately three gallons of commercial muriatic acid are added to the water in each cell and steam admitted to the calandria until the water begins to boil. Steam is then turned off and the solution agitated for six hours by an air jet so placed that it forces a circulation up the center well. The evaporators are now opened and cooled by sprays of cold water, in order to allow the men to work in some degree of comfort. The tubes are easily scraped clean. The advantage of this method over that of boiling with steam for six hours is a saving of steam. The air compressor is motor-driven from power outside of the mill; consequently the boilers are shut down as soon as the evaporators are through with the juice.

An economic practice is that of saving the caustic soda solution from one week to the next. Some factories are thus enabled to get through the season with a very small cost for soda. It is sometimes necessary to add a little fresh caustic, as the solution may become weakened by dilution, by changes effected in dissolving scale material, and by carbonating during the week from the carbon dioxide in the air. I would like to suggest that the solution might be strengthened at less cost by adding milk of lime. This will react with sodium carbonate, sulphate, or phosphate, to form the corresponding lime salt, and leaving caustic soda in solution. The precipitated impurities can be drawn off from the bottom of the holding tank.

It is generally agreed that Yellow Caledonia cane causes more scale than the other varieties. At Wailuku, where there is none of this variety, D 1135 is the cause of most scale. H. D. Beveridge notes that such cane juices as require the largest quantities

* Presented at the 16th Annual Meeting of the Hawaiian Chemists' Association, Oct. 30, 1918.

of lime for clarification usually leave most scale in the evaporators. W. K. Orth finds it of advantage to concentrate juice from Yellow Caledonia cane to a lower density than other juices. If this juice is concentrated to the same high density as is allowable with Lahaina juices, the evaporator capacity is soon so much impaired that any saving in steam or fuel made in the beginning of the week is counter-balanced by the greater consumption towards the end of the week. He prefers with Caledonia to evaporate to a lower density than can be maintained throughout the whole week.

Mr. Horace Johnson reports that he cannot detect any difference in the amount and character of scale formed from juices of different varieties of cane. His observations lead him to believe that this difference is due more to the peculiarities of location and climatic conditions.

At Kahuku, the use of soda ash did not meet with the same success as in former years, but when left out, the amount of scale to be removed increased appreciably. Caustic soda was of no assistance whatever in preventing scale. The juices were of extremely low purity, with Yellow Caledonia and Demerara canes predominating. One contributing cause may be the quality of the lime. This was burned from Island coral, and contained a considerable percentage of magnesia. It is a fact that many factories which are using this lime are not experiencing any additional trouble, but it will be of interest to make further observations in this connection.

I present as a suggestion that this action of magnesia will be accentuated in juices of high chlorine content. It is manifest that under these conditions the possibilities for the presence of magnesium chloride are great, and it is a well-known experience that magnesia chloride in boiler feed water makes for corrosion and pitting of boiler tubes. This is due to the breaking up of magnesium chloride under the influence of high temperature and pressure into a hydrated form of magnesia and hydrochloric acid. Noel Deerr in Bulletin No. 36, H. S. P. A. Experiment Station, showed that at temperatures from 100 to 130 degrees centigrade considerable inversion of sucrose was caused by the presence of many neutral salts, that of these the magnesium salts were the worst and chloride produced the most rapid effect. In ordinary factory operations the juice is not maintained at the temperatures used in Deerr's experiments, but, nevertheless, it is not impossible that the time element will produce an effect similar to the heat influence.

Nothing was developed in regard to the results from pre-evaporators. They are all found to be serviceable savers of steam.

It is a matter of dispute as to where the vapors can be utilized to best advantage, some maintaining very strongly that the juice heaters should receive them, on account of the greater temperature difference and more rapid condensation of the vapors.

Horace Johnson observes that they give the best service when operated evenly, i. e., where the demand for vapor is fairly constant; and are therefore most easily operated when they furnish vapors where there is a steady demand, as, for instance, in heating raw juice and reheating clarified juice.

Conglomerates. Outside of the impression that a slow circulating pan may be responsible, there is no conclusion deducible from the contributions. Conglomerates have apparently been found in process of formation at all stages of the strike, in both coil and calandria pans, in strikes grained on seed or not, and in massecuites of high or low purity. It is doubtful if their formation is easily preventable.

Recovery. This question was suggested to the committee with the purpose of possibly demonstrating that in the boiling-house, as with the mill, the better the recovery at the first crystallization (or extraction), the greater the total recovery. Only one reply was received, and not sufficient figures submitted in this reply. It is a question that is open to argument, and it is hoped it will receive full discussion. It appears to the committee that the conditions are so dissimilar in mill extraction and crystallization, that no parallel exists.

There are several factories which, through necessity or choice, hold the first massecuite in crystallizers for several hours before drying; but unfortunately none of their representatives replied to this committee's questions. It is a process worthy of trial in factories whose high purities require three boilings to reach well exhausted molasses. It may mean more work in the first centrifugals, but also less in the low-grade machines. If it is agreed that a high recovery at first boiling implies a good ultimate recovery, this is one procedure working towards that end.

To the query as to boiling of a 65 and 45-purity molasses, all the replies agree that it would be better to grain on the 65 molasses and finish off with enough 45 to make a 55 massecuite rather than mix the two molasses together and start and finish with 55 material. The committee does not agree with these members. It is admitted that by using a syrup footing and slow boiling, 45 molasses may be boiled on grain. But it does not necessarily follow that a start on the soft grain of a 65 massecuite will be equally efficacious. As a matter of fact, it frequently happens that the 45 molasses is simply boiled down to proof, forms new grain in the crystallizer, and not graining at rest but in motion

produces a quantity of very fine grain. This is mixed with the larger grain of the 65 molasses and produces a very poorly drying, sticky massecuite; and a final molasses whose purity is but little lower than the lower molasses which entered into the strike. On the one hand, a 55 molasses can be boiled readily to grain, and will dry to a good second sugar and low molasses, provided always it is properly handled. A well-boiled 55 molasses should give a 32-33 molasses. On the other hand, a 45 molasses boiled on a 65 molasses footing will probably give not only a 35-36 molasses, but a much lower purity sugar.

The committee expresses its appreciation to the various members whose contributions form the basis of this report.

THE MANUFACTURE OF CEMENT AT PAIA.*

By W. K. Watkins,
Superintendent Maui Agricultural Company's Cement Plant.

About ten years ago the Maui Agricultural Company started burning lime by means of a rotary kiln and using the local coral sand as raw material. The next step was an investigation to determine if a Portland cement could be manufactured from the raw materials to be found at Paia. A number of problems occurred during the investigation and later during the first year of actual operation of the cement plant. These may be divided into four classes as follows:

1. Concerning chemical compositions.
2. Concerning physical tests and characteristics.
3. Concerning the organization and instruction of labor.
4. Concerning mechanical equipment, spare parts and repairs.

In Portland cement the percentage of lime, silica, aluminum, iron, and magnesia are restricted to rather narrow limits. These are approximately as follows:

Lime	57%	to	67%
Silica	20%	"	25%
Aluminum	4%	"	8%
Iron	2%	"	5%
Magnesia	0%	"	5.4%

Early in the investigation of raw materials it was found that

* Presented at the 16th Annual Meeting of the Hawaiian Chemists' Association, Oct. 28, 1918.

there was a shortage of silica and aluminum at Paia, with an excess of iron and magnesia.

Typical coral sand and lava rock would analyze as follows:

	Coral Sand	Lava Rock	Resulting Cement
SiO_2	0.48	45.40	21.66
Al_2O_3	1.40	20.01	5.53
Fe_2O_3	...	17.55	6.27
CaO	50.80	9.59	59.30
MgO	3.38	4.70	4.69
SO_3	...	...	1.15
Ig, Loss	44.62	...	1.54

Additional silica was supplied by the use, at first, of Kieselguhr and later of quartzite brought from the Coast. The amount of silica to be added varied from twenty to forty pounds per barrel of cement and our produce was sound and passing the standard specifications.

The magnesia content is limited to 5.4% by the present specifications, and it was only by careful selection of the field rock that we were able to meet the requirement.

The aluminum and iron may be considered in part interchangeable, but the presence of rather too much iron made the first cement slow setting and it therefore did not meet our general requirements. The initial set was from three to five hours and the final set in from six to nine hours.

While our cement passed the standard specifications on all points, it was desirable to shorten the setting time, reduce the magnesia content, and do away with the need of importing silica in the form of quartzite from the Coast.

After much prospecting and analyzing of the samples obtained, we have found the combination we need by using a mixture of rock quarried at Lahaina with rock quarried at Paia, together with the coral sand. The two rocks are as follows:

	Lahaina.	Paia.
SiO_2	61.98	51.74
Al_2O_3	21.06	18.24
Fe_2O_3	5.40	15.80
CaO	1.63	4.50
MgO	0.60	1.88
Ig, Loss	1.40	4.32

Our average mix contains 450 pounds of coral sand, 35 pounds of Lahaina rock and 75 pounds of Paia rock per barrel of cement.

The resulting cement gets its initial set in from one to two hours and its final set from four to six hours, with a typical analysis as follows:

SiO_2	20.86
Al_2O_3	7.05
Fe_2O_3	3.47
CaO	61.60
MgO	2.99
SO_3	1.31
Ig, Loss	1.90

By varying the proportions we can get a special quick-setting cement that will set within thirty minutes, but is otherwise normal.

We have therefore shortened our setting time by two hours, decreased our magnesia content one per cent and no longer require quartzite from the Coast, and with the exception of about two and a half per cent of gypsum used to regulate the set, use only materials found on Maui. Our product is a Portland cement passing the standard specifications and also meeting our particular requirements as to setting time.

It will be observed that in meeting the problems of chemical composition we also solved some of the problems connected with physical tests and characteristics. In reducing the amount of inert magnesia we were able to increase the amount of lime and so improve the strength tests, while the matter of setting time has been met.

There remained one physical test, the fineness, and its solution depended upon whether we could find a satisfactory pebble to use in our tube mill which did the finishing or final grinding of the cement. To do this in an efficient manner the pebbles must be fairly regular in shape to keep from breaking; smooth to offer sufficient grinding surface, and hard to reduce the cement clinker to the required fineness without adding too much inert material. (The specifications allow but one per cent of insoluble material in the cement.) So far the pebbles found on Maui have not met all these requirements, but we have just put into service some from Kaupo which we believe will be satisfactory. If they are not, we may be forced to use pebbles from the Southern California coast, for the best pebbles from Denmark or France are not to be obtained. In general, the pebbles on Maui have been much too soft, and in the past those which were hard would not wear regular, and spalled badly.

The labor problems have not been due to shortage of labor, but to find labor that could be trained into satisfactory cement-mill operators. The conditions in a cement plant are decidedly unpleasant compared to those in a sugar mill, and as a result labor trained to operate machinery around a sugar mill are not a source of labor for the cement plant. If they know conditions they show no undue haste in applying for jobs; if they don't know conditions and come to work, they generally show

considerable haste in getting away. But we are gradually gathering a force of workmen who know this work and stick with it. The most difficulty has been in training the men who operate the kiln. The Filipino is the only laborer who has not proved satisfactory in any position.

At Paia the raw grinding machinery working on local raw materials has not had the capacity it would have had on average materials elsewhere. We have had additional machinery on order for a number of months, but are uncertain as to when it will arrive. The cement industry calls for a class of machinery and repairs that are manufactured in few places. There are only a small number of articles that are in common with sugar-mill machinery, and these are limited to power and transmission machinery. The local foundries and shops have frequently helped us, but at present the problem of spare parts is yet to be solved. Conditions will improve after the war, but a large stock of repair parts and special supplies will be necessary.

FERTILIZATION AND SUGAR PRODUCTION IN HAWAII.*

By J. A. Verret.

A. AMOUNT OF FERTILIZER TO USE.

We all know that the sugar industry of Hawaii depends to a great measure on the use of relatively large amounts of fertilizer, but how much this is so most of us do not realize.

I propose to give a few figures to show how vitally important the question of fertilization is to us.

In 1909 we harvested experiments which gave results as follows:

Place	Amount of Fertilizer	Tons Sugar
Pahala	None	2.85
"	900 lbs. Fert.†	3.88
"	1200 lbs. Fert. plus 300 lbs. Nit. Soda	5.34
Hakalau	None	1.95
"	900 lbs. Fert.†	3.18
"	1200 lbs. Fert. plus 300 lbs. Nit. Soda	6.81
Kahuku	None	3.58
"	900 lbs. Fert.†	4.34
"	1200 lbs. Fert. plus 300 lbs. Nit. Soda	7.27

* Presented at the 16th Annual Meeting of the Hawaiian Chemists' Association, Oct. 28, 1918.

† Fertilizer = 6¼% N., 5% P_2O_5, 13% K_2O.

At Waipio an experiment this year gave the following results:

No fertilizer	1.85 tons sugar
484 lbs. nitrate	5.16 " "
1130 " "	6.11 " "

This was short ratoons, of H 109 and D 1135.

On virgin land on Oahu, we obtained the following results:

No fertilizer	5.93 tons sugar
75 lbs. nitrogen	6.73 " "
150 " "	7.30 " "
225 " "	7.71 " "

From the above results we see that on land which has been cultivated for some years, without fertilizer the yields would drop to about two or three tons of sugar per acre instead of what we now obtain.

On the other hand, the results of experiments indicate that with ratoons, in the majority of cases, the limit of profitable application is 200 pounds or more of nitrogen per acre.

With plant cane the response is not always so emphatic. Especially is this the case with fields which have been fallowed for two or more years. In such cases we have obtained no increase in yield from the application of fertilizer from experiments harvested in the last two years.

At Grove Farm a field fallowed three years, plowed four times and pastured to cattle, gave the following yields:

No fertilizer	7.34 tons of sugar
150 lbs. nitrogen	7.44 " " "
300 " "	7.21 " " "

In another experiment in the same field the results were as follows:

250 lbs. N. mixture (15% N.) gave 7.48 tons of sugar
500 lbs. N. mixture (15% N.) gave 7.44 tons of sugar

compared to 7.34 tons of sugar from neighboring plots receiving no fertilizer. Results of the same nature were obtained last year at Grove Farm and Kilauea.

B. NUMBER OF DOSES.

From the results being obtained during the last few years it would seem that in applying a given amount of fertilizer better results are obtained when the fertilizer is applied in few large doses rather than in many small doses.

To illustrate this, I give the following figures from Experiment S, at Waipio, short ratoons, harvested this year:

One dose	5.90 tons sugar
Two doses	5.82 " "
Three doses	5.31 " "

On Oahu, applying two tons of nitrate of soda in 20 doses, one every two weeks in the irrigation water, did not produce as much sugar as did half a ton of nitrate when applied in four doses, two the first and two the second growing season.

Results of a more or less similar nature have been obtained on Hawaii and on Maui.

C. FORMS OF NITROGEN ON IRRIGATED PLANTATIONS.

The indications are that there is but little difference in the value of equal amounts of nitrogen when obtained from soluble salts. The averages of four crops at Waipio were as follows:

Nitrogen	from	nitrate of soda	4.22 tons sugar per acre
"	"	½ nitrate, ½ ammonium sulphate	4.28 " " " "
"	"	nitrate of lime	4.22 " " " "
"	"	ammonium sulphate	3.98 " " " "

The slightly lower yields from the ammonium sulphate plots is to some extent caused by Lahaina disease.

In an experiment with young plant (planted last April) now being conducted at Waipio, dried blood is being used in place of nitrate of lime, the rest remaining the same. The cane in the dried blood plots is not growing as fast as in the rest of the experiment, nor has it as good a color.

D. PHOSPHORIC ACID.

Phosphoric acid should be used on all fields in these Islands, unless otherwise indicated by field experiments.

The limit of profitable application appears to be between 60 and 90 pounds of P_2O_5 per acre. Applications above 90 pounds have not been profitable.

At Pepeekeo last year the use of basic slag in addition to 70 pounds of P_2O_5 from high grade produced no additional increase in yield.

At Honomu, during the same season, the addition of phosphate was of no apparent benefit.

At Kilauea, in one field harvested this year, the use of reverted phosphate in addition to 27 pounds of P_2O_5 from high-grade fertilizer, produced no gain.

On the other hand, in other fields on this plantation, the addition of reverted phosphate to young 1920 plant was distinctly beneficial to the young cane. The cane receiving the phosphate is very much better, being taller with a much better color.

The same thing is being noted at Grove Farm.

In Oahu Sugar Company experiments, harvested this year,

Fig. I. No reverted phosphate.

Fig. II. 500 pounds reverted phosphate per acre.

The cane represented above is Yellow Caledonia plant, in virgin land, not irrigated. The cane was planted at the same time and received identical treatment, except that that shown in Fig. I did not receive phosphate, while that in Fig. II received 500 pounds reverted per acre.

gains of from 0.5 ton to 1.40 tons of sugar per acre were obtained from the use of varying amounts of P_2O_5. Applications of over 90 pounds of P_2O_5 produced no further profitable increase in yield.

Slightly greater gains were obtained from superphosphate than from reverted phosphate.

In the light of recent experiments it would seem the virgin land especially responds very favorably to phosphate applications.

D. POTASH.

The addition of 250 pounds of sulphate of potash per acre increased the yield of sugar .50 ton at Onomea this year.

At Waipio, on the other hand, adding 75 pounds of K_2O did not increase the yield.

In this same experiment 200 pounds of nitrogen and no phosphoric acid or potash produced 0.48 ton of sugar more per acre than did 150 pounds of nitrogen plus 75 pounds P_2O_5 and 75 pounds of K_2O.

On the Oahu new lands, 90 pounds P_2O_5 in addition to nitrogen produced a gain of 1.30 tons of sugar, while in an adjoining experiment, 90 pounds of P_2O_5 plus 60 pounds K_2O, in addition to nitrogen, produced a gain of 1.40. From these results one would judge that the potash was of very little if of any value.

SUMMARY.

The results obtained so far in our experiments justify us in making the following more or less broad conclusions:

1. The majority of the plantations have not yet reached the profitable limit in the application of nitrogenous fertilizers. This limit, in the great majority of cases, is above 200 lbs. of nitrogen per acre, assuming other cultural operations, such as irrigation, weed control, etc., to be adequate.

2. An exception to the above has been noted on Kauai with plant cane on lands previously devoted to fallowing and turning under the volunteer growth of grass and weeds, including some legumes. In a number of such instances, plant cane failed to respond to fertilizer. On the other hand it should be noted that in virgin soil on Oahu, applications of 150 lbs. of nitrogen proved profitable.

3. In approaching the profitable limit in the use of fertilizer, the increases due to fertilizer become less and less as this limit is approached. The tendency of our plantations is to be con-

servative and fall short of the limit. It may be a better policy to slightly exceed this limit, as in this case we lose the cost of the fertilizer and in the other case we lose sugar of an even greater value. It would therefore seem part of good agriculture and good business for the plantations to determine by experiment over as wide a range of soil conditions as feasible the profitable limit of nitrogenous applications.

4. A few large doses of fertilizer give better results than many small ones. There seem to be no exceptions to this in the experiments conducted so far. By a few large doses we mean not to exceed four—two in each growing season, or, if the crop has a late start, divide the fertilizer into three doses, applying only one the first season. In one year cropping, one dose of fertilizer has given better results than two or more under irrigated conditions.

5. We have had little or no success in increasing yields by growing legumes between cane rows.

6. In a great many cases, nitrogen alone has paid better than an equal money value of complete fertilizer, but there are some exceptions where phosphoric acid and potash have given profitable returns.

7. No general statement can be made in regard to the value of supplementary doses of phosphoric acid or potash. Some experiments indicate a loss, others a gain. Until more data are obtained through soil analyses and field tests on a wide range of fields, we would recommend the use of some phosphoric acid on each crop, unless field experiments have indicated otherwise for a particular locality. The use of some potash appears desirable in fields containing less than 0.25% total potash, unless the contrary has been shown by local field tests. This potash should be obtained preferably from final molasses.

8. The results of four years' tests at Waipio show no great difference in the value of nitrogen when obtained from different nitrogenous salts. Equal weight of nitrogen from nitrate of soda, sulphate of ammonia, a mixture of nitrate and sulphate, and nitrate of lime, were tried.

9. On Hawaii and Kauai we have harvested experiments showing no increase from liming, but the conditions of the tests are not altogether satisfactory and further testing on this score is thought advisable. On non-acid soils on Oahu, coral sand or lime increased the yields of Lahaina and H 109. With D 1135 there was no gain.

10. As fertilizer is increased above a moderate amount, the quality of the juice falls off, but up to the profitable limit, which in many cases ranges between 200 and 300 lbs. of nitrogen per

acre (about 1400 to 1700 lbs. of nitrate), the loss in quality is made up by the heavier yields in cane.

11. We have not yet obtained any evidence that either potash or phosphoric acid improves the quality of the juices.

12. Gypsum has not yet given any positive indications of being a cure for so-called Lahaina disease, although in some cases its use seems to be of benefit.

DETERMINATION OF SUSPENDED SOLIDS IN MIXED JUICE.*

By H. Laurence White.†

The determination of suspended solids in mixed juice as prescribed in Methods of Chemical Control, H. C. A., 1916, is not only difficult, but slow—difficult because the solution will hardly filter through a close-textured paper and if a vacuum is applied the paper invariably breaks. The wash water passes through so slowly that the method is almost impracticable on account of the time necessary to make a determination. Methods involving the use of the Gooch crucible filter, filter paper, mat filters using cotton, asbestos, gauze and cloth have all failed to meet the requirements of nearly perfect separation of juice and suspended solids within a reasonable length of time. What is needed is a quick, accurate and thoroughly reliable method. With these last points in mind I submit the following method with my criticism on it:

Take 100 grams of mixed juice, well sampled, add 400 grams of water, and mix thoroughly.

The filter consists of an extraction thimble, Whatman make, 33 x 94 mm. A gauze basket placed in a copper jacket with a smooth-faced surface next to the upper part of the extraction thimble forms the rest of the filtering device. The faced surface next to the paper thimble forms the seal for the vacuum. The copper jacket has a tube soldered at the bottom to be run through a cork and placed in the regular filtering flask. The basket and thimble are two separate parts.

With this filter and the sample of mixed juice made up as

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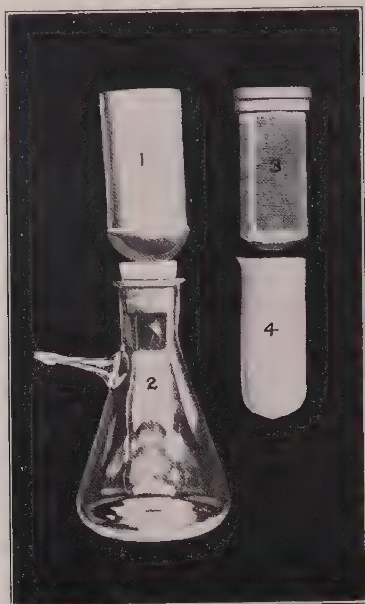
* Presented at the 16th Annual Meeting of the Hawaiian Chemists' Association, Oct. 29, 1918.

† Member Committee on Methods.

described, the determination may be made in about five minutes. The filtrate after passing through is very clear, and upon refiltering no more solid matter will be removed. Washing is easy and there is no need to slight a good washing of the solids because the water runs through rapidly. One thimble is good for three or four determinations before it becomes sluggish. The copper part was made up in the shop and could easily be duplicated anywhere.



White Filtering Funnel.

REPORT ON CLARIFICATION AND FILTERING.*

By Geo. F. Renton, jr.

From the replies received from the different members of this Association, in answer to the questions on "Clarification and Filtering," I conclude that no changes of importance have been

* Presented at the 16th Annual Meeting of the Hawaiian Chemists' Association, Oct. 29, 1918.

made at either of these two stations during the crop of 1918. However, in comparing the different answers that were received, a number of ideas and suggestions were advanced which may be of some interest.

Suspended Solids. We all know that the weighing of mixed juice is more accurate than measuring it; that recording beam scales and automatic counters, recording the number of scales weighed, are steps taken to insure more accurate chemical control, yet, on the other hand, some of us fail to realize the fact that the suspended solids present in the mixed juice are a source of error unless they are determined daily and deducted from the weight of the juice. The percent suspended solids, as reported to me, ranged from zero to 1.13%. Supposing a factory handling 390,000 tons of mixed juice during a season made an error by not deducting 0.25% of this weight for the suspended solids present, and assuming that this mixed juice contained 10% of sugar, they would report as entering the boiling-house 97.5 tons more sugar than was actually received. In other words, they would credit the boiling-house with receiving sugar that did not exist and of an amount that would, generally speaking, equal the total amount of sugar lost during the season in the filter-press cake.

Lime and Heat for Clarification. The consensus of opinion is that milk of lime is the most satisfactory way of handling this reagent, and that this be added to the mixed juice as it is being discharged from the weighing tanks into the receiving tank below. A very convenient arrangement for handling this milk of lime is to have a tank of about 10 gallons capacity placed between the juice scales and at a level which would be convenient for the operator. This container acts as a measuring device and the correct amount of the milk of lime can be emptied into the stream of juice as it flows from the scale tank. This juice, with the added lime, should be kept in constant agitation to insure thoroughly mixing, and this may be done either by compressed air or by a revolving propeller in the receiving tank under the scales.

From August 12 to August 28 a simple experiment was tried at the Ewa mill to see if any difference could be noticed at the settling tanks or in the clarified juice when different temperatures were used at the heaters. As the settling tanks are large, it was arranged to fill every other tank with juice at 204° F. and compare the results obtained here with those from the remaining alternating tanks, which were filled with juice at 212° F. This was continued for nine days, from twenty to thirty-six separate determinations being made per day and the average for

the day recorded. A similar test was made comparing results obtained when heating the juice to 218° F. with that of 212° F. The results obtained were as follows:

TEMPERATURE OF JUICE, 212° F.

Date, 1918	Clarified Juice			Time taken for Complete Settling
	Brix	Pol.	Pur.	
August 12	12.23	10.19	83.32	
" 13	12.32	10.29	83.03	
" 14	10.22	8.59	84.05	
" 15	11.86	10.13	85.41	53 minutes
" 16	11.81	10.04	85.01	51 "
" 17	12.49	10.79	86.39	60 "
" 19	12.37	10.54	85.21	46 "
" 20	12.44	10.69	85.86	49 "
" 21	12.10	10.16	83.97	47 "
	11.98	10.16	84.81	51 minutes

TEMPERATURE OF JUICE, 204° F.

Date, 1918	Clarified Juice			Time taken for Complete Settling
	Brix	Pol.	Pur.	
August 12	12.39	10.36	83.61	
" 13	12.24	10.28	83.99	
" 14	10.39	8.76	84.32	
" 15	11.82	10.14	85.79	56 minutes
" 16	11.79	10.01	84.90	50 "
" 17	12.22	10.56	86.42	57 "
" 19	12.14	10.31	84.93	41 "
" 20	12.43	10.55	84.90	48 "
" 21	12.17	10.21	83.90	49 "
	11.95	10.13	84.77	50 minutes

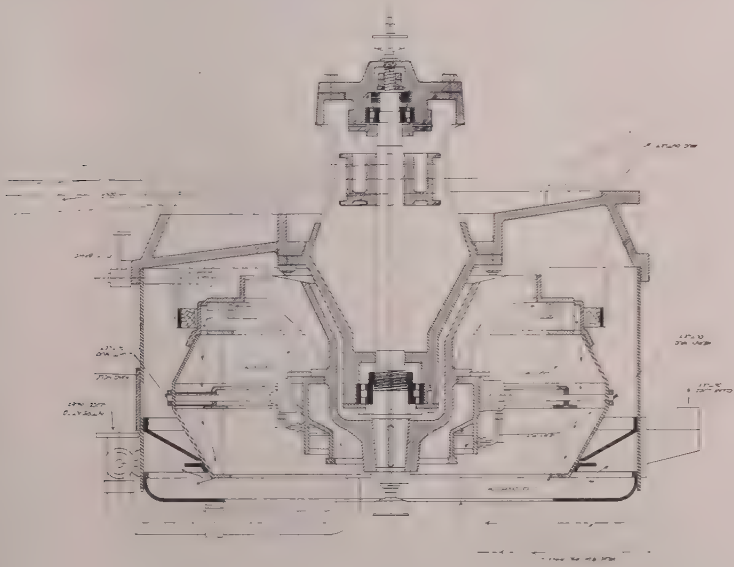
TEMPERATURE OF JUICE, 212° F.

Date, 1918	Clarified Juice			Time taken for Complete Settling
	Brix	Pol.	Pur.	
August 22	11.62	9.80	84.36	51 minutes
" 23	11.64	9.93	85.35	56 "
" 24	10.60	8.97	84.69	51 "
" 26	11.94	9.90	82.82	58 "
" 27	11.54	9.48	82.13	48 "
" 28	9.91	7.98	80.59	47 "
	11.21	9.34	83.32	52 minutes

TEMPERATURE OF JUICE, 218° F.

Date, 1918	Clarified Juice			Time taken for Complete Settling
	Brix	Pol.	Pur.	
August 22	11.54	9.70	84.05	52 minutes
" 23	11.70	9.98	85.30	52 "
" 24	10.75	8.99	83.70	51 "
" 26	11.88	9.85	82.91	56 "
" 27	11.29	9.23	81.78	49 "
" 28	9.92	8.00	80.69	42 "
	11.18	9.29	83.09	50 minutes

The test conveys the idea that, as far as heat is concerned for clarifying cane juices, any temperature from 204° F. to 218° F. is satisfactory. This may be true as far as clarification is concerned, but it will be noticed that when the initial temperature of the juice dropped below 206° F., trouble was experienced in the filter press station, the filter presses not doing their work, due to the slimy consistency of the mud on the filter cloth. The conclusion derived from this test is that in heating juice for clarification, it is not advisable to heat the juice lower than



Hamill Centrifugal Separator.

208° F., and that any temperature from 208° F. to 218° F. will give satisfactory results.

The precipitate and scums caused by the combined action of the heat and lime together with the suspended matter, and other foreign material, may be separated from the mother liquor by filter presses with the aid of Kieselguhr, Filter-Cel, and the like; by mechanical means, as the Kopke clarifier or Hamill's centrifugal separator, or by the more common practice, settling tanks of either the continuous or intermittent type.

Direct juice filtration with the aid of Filter-Cel was fully covered last year, and the Kopke clarifier is well known to all of us, but the Hamill juice centrifugal may need a word of explanation. I quote in full a report by Mr. James Hamill on the preliminary trials of Hamill's centrifugal separator in a sugar refinery carried out from November, 1914, to February, 1915. This report was sent to me by Mr. S. S. Peck:

REPORT OF PRELIMINARY TRIALS OF HAMILL'S CENTRIFUGAL SEPARATOR IN A SUGAR REFINERY.

Tests carried out from November, 1914, to February, 1915.

The machine was erected in a sugar refinery in Greenock, which dealt with very low purity sugars only. The sugars treated were the native products of Brazil and India, and had a purity of about 80%, with a density when melted of 65% to 70% sugar, and a temperature of 160° to 180° Fahr.

The filtration process in use consisted of the usual Taylor bag filters, followed by char filters to give a limpid liquor. The liquor turned out by the bag filters was quite brilliant and of a dark amber color, but owing to the extremely viscid and gummy nature of the melted liquor, great care and frequent cleaning were required to obtain this result, the cleaning time being 70% of the total.

Owing to the war, and to the fact that the centrifugal maker's works were being used for Government purposes, it was impossible to have replaced a faulty casting in the drum of the machine, therefore the full speed of the drum could not be attained. It was decided, however, to proceed with the tests, and determine if the principle of the machine was correct.

The machine was a small one, with a 30-inch drum, made specially for experimental purposes, and the designed speed was 1350 R.P.M. This had been guaranteed by the makers, but owing to the aforementioned defect, the actual running speed was only 900 R.P.M. The centrifugal force at the separating zone was, therefore, only 250 times gravity instead of 500 as designed.

The arrangements for driving the machine consisted of an electric motor on a 500-volt circuit, and the amperes were found to be 6., making the energy used 3 K.W.

Owing to the density and stickiness of the liquor, no clarification by ordinary subsidence was possible, even in the test tube, as there seemed to be no difference of specific gravity between the liquor itself and the impurities. Being fed to the machine, however, great quantities of the

finest mud and gums were collected in the machine at the designed place. The valve arrangements acted in the desired manner, so that the collected impurities were discharged evenly at will when the machine was in operation. Consequently, no stops had to be made to remove the mud, and the machine could be kept running on juice all the running time. An automatic arrangement, consisting of a small water cistern, operated the valves, and required no attention except the regulation of a small valve on the water supply to same. The water used was about 7 gallons per hour, and helped to dilute the mud.

The amount of heavy liquor treated per hour varied from 300 to 400 British gallons (10 lbs. water), and had the designed speed been attained, this would of course have been increased, in proportion to the increased centrifugal force generated, and in this case doubled.

It had not been claimed that any separation would be obtained on a liquor which was not capable of treatment in a subsiding tank, or where the specific gravity of the impurities approximated the liquor. The results were therefore very gratifying, and were in advance of the refinery people's expectations.

The overseer of the refinery has had experience of raw sugar factory work in India and the East, and his unqualified opinion was that the machine as it stood was capable of turning out a clarified liquor on raw sugar, the liquors being much less dense and more amenable to the action of subsidence.

The principle of the machine, therefore, has been thoroughly proved, and the following are the main deductions from the tests which were personally conducted:

(1) The heavier than liquor impurities were collected and discharged at the desired points, whilst the machine was in operation at full speed.

(2) The lighter than liquor impurities were collected and discharged in a like manner.

(3) The discharging valves proved reliable and positive in action, both for light and heavy impurities.

(4) The quantity of liquor treated was commercially successful.

(5) When in operation no attendance was required to stop and clean out the collected muds, these being discharged automatically, whilst running in regular operation, by the valves.

JAMES HAMILL.

The system of intermittent settling practiced at the Ewa Plantation Company is as follows:

The operator, at the juice scales, weighs the juice in recording beam scales, adds the required amount of milk of lime (which has previously been made by the men at the filter-press station and pumped to a tank near the juice scales), operates the pumps feeding the juice heaters, watches the temperature of the juice from the heaters by aid of a recording thermometer (a Tagliabue temperature controller regulating the temperature on the last heater), and controls the effect of the heat and lime on the juice by the aid of samples in test tubes and with litmus paper. A small stream of juice is continually running from a sample pipe connected to the discharge line of the heater back to stand near the operator at the juice scales. A rack holding fifteen 1″x 6″

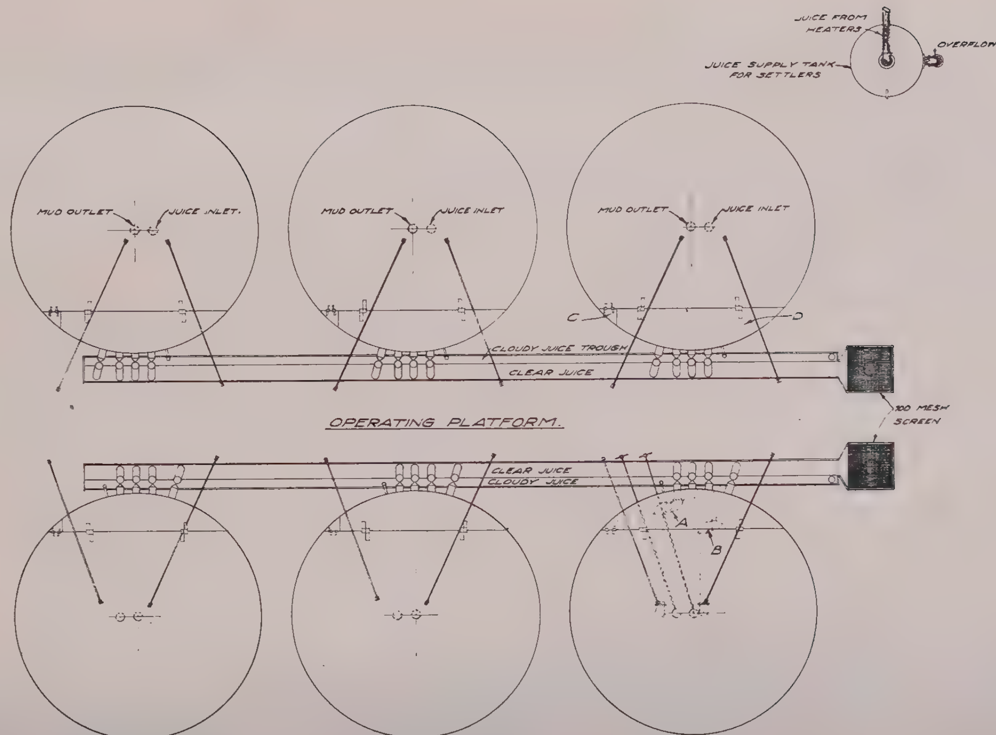


Fig. 1.

Plan of Settling Tanks, Ewa Mill.

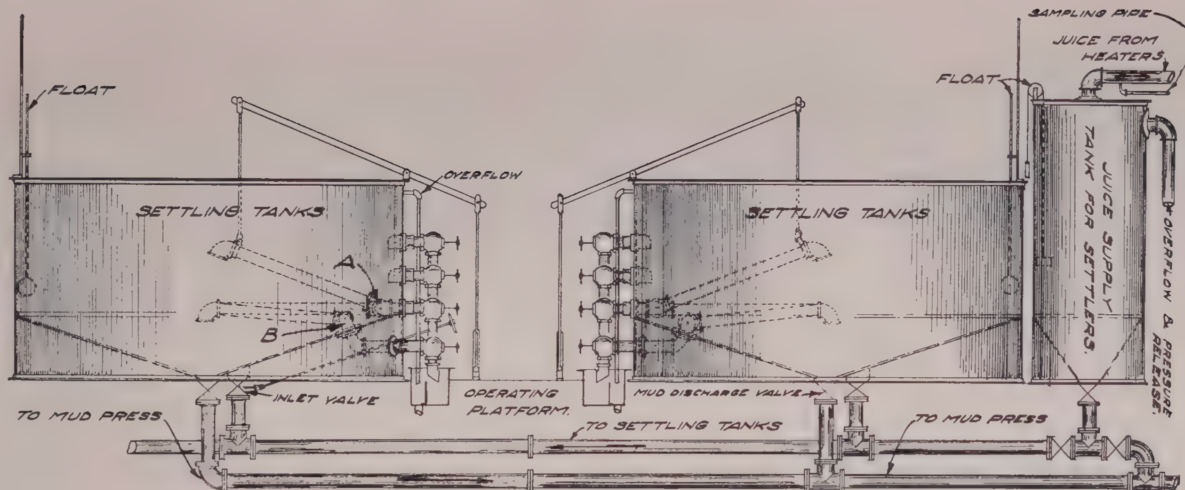


Fig. 2.

Fig. 2. Elevation of Settling Tanks, Ewa Mill.

test tubes is on this stand, and the operator, by taking frequent samples in these test tubes and watching the results obtained here, can, with the aid of litmus paper, accurately control the work in the settling tanks.

The settling tanks are six in number, capacity 7500 gallons each, placed in two rows of three facing on a common operating platform which runs between them. They are round tanks with conical bottoms, insulated with asbestos and wood lagging and completely covered on top, the height of the juice in each being indicated by a float. They are filled from below by gravity from the supply tank, which in turn receives its juice from the heaters; the idea being that in this way the juice is fed to the settlers with the least amount of agitation possible, and the violent disturbance caused by pumping juice directly into the settling tanks through pipes which discharge the juice into the tanks from above is to a great extent eliminated. The valves which control the filling and emptying of the settlers are operated from the platform.

There are two doors in the cover of each tank, a small one "C," Fig. 1, for the adding of reagents, when necessary, and the large one "D" for allowing men to enter them and clean them properly.

Each tank is fitted with four draw-off valves and one overflow pipe; the draw-off pipe is arranged so that the juice may be discharged into either the cloudy juice or the clear juice trough; the overflow pipe discharges into the cloudy juice trough only. As shown in the drawing, Fig. 1, there are two juice troughs, one for each set of three settling tanks, each juice trough discharging onto its own juice screen at the lower end.

The two lower draw-off pipes are fitted with a loose nipple between two elbows, as shown at "A" and "B." By means of a lever arrangement from the operating platform, pipe "A" can be raised almost to the level of the first outlet and pipe "B" to the level of the third outlet. In this way, the tanks can be emptied quicker, greatly increasing the capacity of the apparatus. Furthermore, by aid of pipe "B" most of the clarified juice can be removed from the settling tanks, relieving the filter-press station considerably, as only about 8% of the contents of these settling tanks is sent to the filter-press station.

To ascertain which would be the best grade of wire cloth to use for removing "cush-cush" and other foreign matter from the clarified juice before passing to the evaporators, a careful record was kept during the crop of 1918. One half of the clarified juice passed through 100-mesh cloth at the end of one trough, and the balance through 200-mesh cloth at the end of the other. The weight of cush-cush reported represents the foreign matter

alone, not the weight of cush-cush and juice as obtained on the screens. The results were as follows:

	Sq. Ft. Used, Crop 1918	Cost of Same	Pounds of Cush-cush Removed	Cost per 100 Lbs. Cush-cush	Cost of Screening per Ton Sugar Manufactured
100-mesh ...	18.54	$23.18	2466	$0.94	$0.00066
200-mesh ...	22.02	96.89	2592	3.74	0.00274

In reply to the questions, time taken to fill a settling tank; time juice is allowed to settle; and time taken to discharge the clarified juice, the factories equipped with settlers of the intermittent type made answers which are collected in the following table:

	Time (in minutes)—				Per Cent of Total Time—		
	To fill settling tanks	Juice is allowed to settle	Taken to dis-charge	Total	To fill settling tanks	Juice is allowed to settle	Taken to dis-charge
Ewa	20	17	78	115	17.4	14.8	67.8
Wailuku	12	40	50	102	11.8	39.2	49.0
Pioneer	30	75	50	155	19.4	48.4	32.2
Koloa	14	25	27	66	21.2	37.9	40.9
Paauhau	13.5	32	48	93.5	14.4	34.2	51.4
Hakalau	12	70	22	104	11.5	67.3	21.2
Kohala	15.5	21.5	21	58	26.7	37.1	36.2
Onomea	10	60	30	100	10.0	60.0	30.0

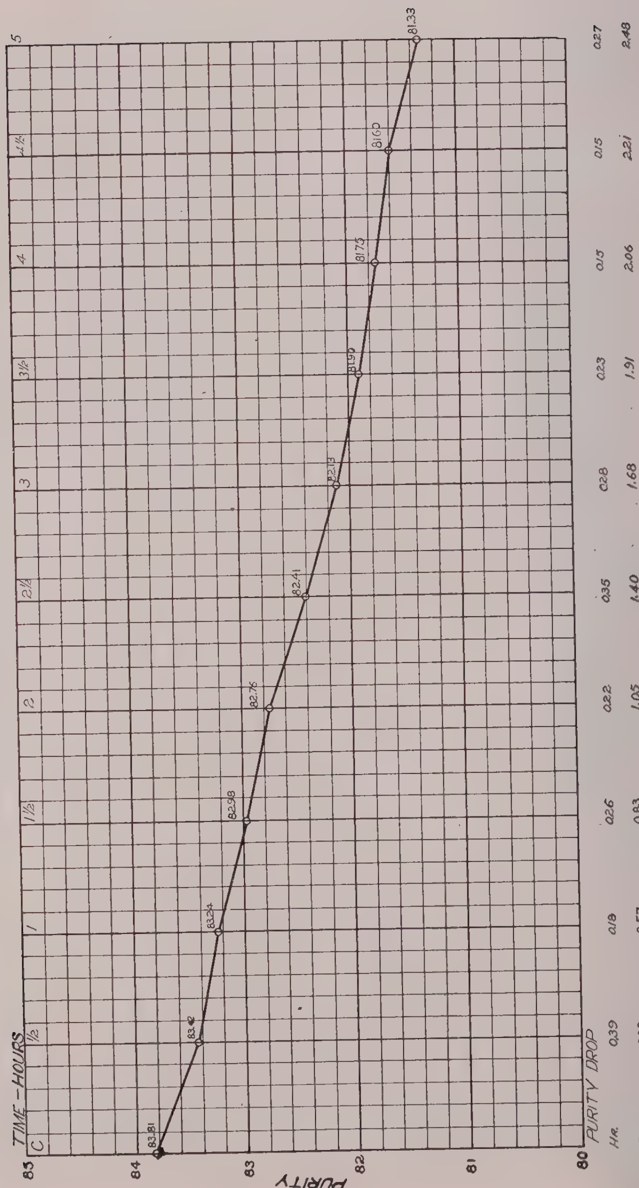
Filter Presses. When the sediment is discharged from the settling tanks and sent to the filter presses, lime is usually added to facilitate filtration, and this mixture is heated in the mud-press supply tank before it is forced into the presses. Care should be taken to see that these scums are not heated too long, as is shown by the following diagram, which is an average of twenty-three laboratory experiments.

A bucketful of sediment was caught as it came to the filter-press station. A small portion of this was taken for analysis, the balance being heated in the bucket by turning steam into the scums through a ½″ pipe. Every half hour a sample was taken, filtered, and the purity of the liquor determined.

To prevent the possibility of heating the scums too long, the mud-press supply tank should not be larger than is absolutely necessary.

The gravity system of filling filter presses is becoming more popular every season, due to the fact that it is simple, efficient and fool-proof; no more speeding up the pump or montejus when a new press is cut in, and no more fear of the men using too high a pressure, breaking the cloth and filter-press frames. To

EFFECT OF STEAM ON SETTLING OF JUICE



work filter presses properly, it is essential that a full cake be obtained, otherwise the bulk of the washing water will pass through where there is the least resistance and the loss in sugar for that press will be high. To fill a press properly the maximum pressure must be maintained to the last, and this is assured by the gravity system, for it does not matter how many new presses are started, as long as the supply lasts, the pressure will be the same.

In "sweetening off" the filter-press cake to remove the sugar, it is a good plan to use first the last washings from the preceding press, which are low in sugar, and then finish off with pure water, which in turn will be used again in the following press. In this way, the quantity of water used is diminished, making it easier for the evaporators.

A test was conducted, covering a period of three weeks, for the purpose of determining what the Brix and purity of the washings from the presses would be at the end of the first hour, second hour, etc. The schedule adopted was as follows:

Filling presses, 3 hours; sweetening off with return juice, 2 hours; followed by washing with pure water for 6 hours.

		Brix	Pol.	Purity
Analysis of juice from presses prior to washing		12.17	10.31	84.72
Return Juice	At end of 1st hour...	6.61	5.59	84.57
	At end of 2nd hour...	3.35	2.73	81.49
Fresh Water	At end of 3rd hour...	2.07	1.67	80.68
	At end of 4th hour...	1.60	1.22	76.25
	At end of 5th hour...	1.10	0.83	75.46
	At end of 6th hour...	0.91	0.68	74.73
	At end of 7th hour...	0.80	0.56	70.00
	At end of 8th hour...	0.53	0.32	60.38

It is not necessary, in daily practice, to carry the process of washing the presses as far as this; my only reason for quoting this experiment is to show how low the washings are from a press when sweetening off is continued for many hours.

If the sugar content of the press cake, as it leaves the factory, is between 1-1.5%, I think you will agree with me that the work of the filter-press station is good.

Mr. S. S. Peck has contributed some observations on a phase in the handling of juices which has lately come into prominence and which bids fair to assume great importance.

Mr. Geo. F. Renton, Jr.,
Chairman, Committee, Clarification and Filtering,
Hawaiian Chemists' Association, Honolulu.

Dear Sir:—Clarification has been generally defined as a combination of a chemical and mechanical process, chemically being a precipitation of insoluble salts, coagulation of albuminoids and transformation of certain juice constituents; while the mechanical refers to the sedimentation of these and with them the bulk of suspended matter. The purpose of this paper is to present arguments that a new theory of condition of matter may apply very directly to our clarification and filtering problems.

This new theory of matter, now known as Colloid chemistry, originated with Thomas Graham in 1861 to 1864. Since this time it has been wonderfully developed, but theory has so crowded on theory and contention on contention that the first pilgrimage of a novice into this new realm is extremely hazardous to him and in all likelihood very confusing to those to whom he is trying to act as guide. It is, however, of moment that we as sugar chemists begin to formulate our theories as regards certain phenomena in sugar manufacture in accord with these new discoveries.

First, let us see if Colloid chemistry may be deemed applicable to our work. One of the great authorities on this new science, Ostwald, stated in a series of lectures delivered in the United States in 1913: "We see an illustration of this in the refining of sugar. In this, the sugar is separated from its colloid accompaniments by processes of diffusion, of dialysis, etc. We are face to face here with technical questions through the solution of which I was told in America fortunes may be made. Various cane-sugar molasses, containing great quantities of sugar, are sold, for instance, as cattle feed, simply because the sugar cannot be separated from its colloid accompaniments. We no doubt deal in these instances with adsorption compounds between pectin-like substances and sugar, and the colloid-chemical problem involved is that of the destruction of this combination."

Next, what is a colloid? The name was first applied by Graham to substances, such as gelatin, albumen, silicic acid, and aluminum hydroxide, which do not diffuse. The more modern view is that colloids are an intermediate state between true solutions and mechanical suspensions. In a plainer statement, they are suspensions of either solid or liquid phases which will pass unchanged through filter paper or filters of relatively large openings. The limit has been arbitrarily set at one ten-thousandth of a millimeter. Hard filter paper has openings about ten times this size, while some fine porcelain filters approach it. Colloids would therefore be held back by very fine porcelain filters.

Colloids are, then, suspensions of matter in some medium. Some of these suspensions, as of clay, are what we familiarly recognize as solid matter; others, as of gelatin, we are accustomed to term a solution. These suspensions may be collected into larger particles, or coagulated, as it is termed, when they are said to have lost their colloidal character. Thus, by means of salt or an acid, we can so treat a clay suspension that the particles collect into larger aggregates and can be collected on filter paper. Albumen may be thus coagulated by heat. A clay suspension which has been coagulated and separated, may be restored to the colloidal form by treatment with alkali; i. e., the operation is reversible. In a very general way, we may term a colloid a substance in a very fine state of division which does not dialyze and which cannot be

analyzed microscopically. Transition systems exist between the classification; and the line of demarkation between a molecular solution and colloidal solution, on one hand, and a colloidal solution and suspension of solid matter, on the other, is rather vague.

Now, has the theory of colloidal chemistry been applied directly or indirectly to the science of sugar production, consciously or unconsciously? I have at hand four instances to which I shall refer at length.

Dr. R. S. Norris, in the Planters' Record, Vol. 9 (1913), page 593: Filtering juices through Chamberlain filters, the results showed increases of purity of from 0.8 to 2.7 in first mill juices and from 2.2 to 8.8 in last mill juices. He explains this difference from the fact that a considerable part of the impurities of the last mill juices might consist of flocculent matter in suspension derived from cells of cane and that: "The increase in purity in the first mill juices is less than with the last mill juices, which would be expected, since a larger proportion of the non-sugars in the latter case was suspended solids." From the definition we have had of colloidal matter, I believe that you can suspect that the greater proportion of this difference is due to the larger quantity of colloidal matter in the last mill juices. Analyses of juices from different mills show that the later expressed juices contain a larger proportion of gums, pectins and mineral matter which is in a colloidal condition.

Noel Deerr in the International Sugar Journal in 1916 described experiments as follows: "Strained cane juice is an opaque liquor; on filtering this material through asbestos over reduced pressure a pale brown transparent liquid is obtained; only very small quantities can be filtered, since the filtering medium very soon becomes choked; the bodies which have been caught on the filter were evidently in the colloid state. On heating cane juice a separation of the colloids is also obtained, this separation occurring in the neighborhood of 190° F. Colloids once coagulated by rise of temperature do not pass into the colloid state on cooling, and hence the condition is irreversible as regards temperature. Second, the colloids when coagulated by the addition of alkali resume the colloid state on neutralization of the alkali, and hence the colloidal state is reversible with reference to alkalinity and acidity. A calculation gives a rise in purity in one instance of 1.21 units as due to the removal of the colloids as obtained by filtration, and a maximum of 1.69 units as following on the combined action of lime, heat and filtration; that is to say, 72% of the maximum rise is due to filtration and the balance of 28% is to be ascribed to the 'chemical' action of the lime."

Walter L. Jordan in a contribution to the Committee on Clarification at the last Chemists' meeting described experience in filtering juices through Keiselguhr whereby a considerable improvement in the quality of the juices and an increase in purity of the juices are obtained. At that time it was the opinion that, inasmuch as filtration removed only mechanically-suspended matter, the increase in purity was more apparent than real and no extra recovery of sucrose could be anticipated as a result of increased purity. Viewed from the new standpoint of a colloidal condition of matter in the juices and a more or less complete removal of the colloids from the juices due to the Keiselguhr filtration, you may have to conceive the possibility of a direct advantage from this procedure.

Max Schneller in the Louisiana Planter, January 15, 1916, described experiments in the decolorization of cane juices, and in establishing the

cause of color in the juices, laid particular emphasis on the presence of tannin compounds in the juices. He does not use the term colloid, but let us note what rôle tannin plays in colloidal chemistry. Tannin compounds have been found to act as typical protective colloids; i. e., if a colloidal character has been produced in a substance, the particles will be surrounded by strongly hydrated tannin or tannin compounds and so prevented from running together into larger aggregates.

CONCLUSIONS.

What are the colloids in juices? In addition to the tannins already mentioned, are principally the albuminoids, which are eliminated, and pectins or pectinous substances which persist into the molasses. There may be—please note I say "may be", as I am now in the realm of speculation—certain organic and inorganic substances which are in a state of colloidal suspension in the settled juice, and are in part eliminated during concentration. Thus we find the precipitated or aggregated colloidal material as scale in the effects. A fairly constant and extremely disagreeable component of scale is silica. This is introduced in part as suspended matter, such as soil, etc., but also as a component part of the ash of the juice. The evaporation of juice, whether through concentration of electrolytes or by dehydration of the silica compounds, causes molecular aggregations of the silica or silicates to form on the tubes, along with organic matter. It is these silicates also which bear an important effect in hindrance of filtration. The evidence of beet-sugar men who have suffered from limes high in silica will confirm this.

This report is presented with no other purpose than to call the attention of chemists to this new field of investigation. While competent investigators are developing the science, we should try to apply the present theories of colloidal chemistry to our own peculiar problems. If we are confronted with a poorly settling juice which is not benefited by the usual chemical panacea, let us look upon it as a colloidal phenomenon, and attempt such treatment as suggested by this condition which may tend to correct it. Today it may be hard to achieve this; but the tomorrows will eventually bring us, or we shall ourselves find, the correct procedures.

Yours very truly,

(Signed) S. S. PECK.

DIRECT MACERATING AND JUICE-STRAINING SYSTEM.*

By A. KRAFFT, R. R. HIND and C. BOSSE.

The primary aim in modern cane-sugar milling practice is to obtain as high an extraction as possible; that is, to extract as much of the sugar or sucrose content of the cane as is practi-

* Presented at the 16th Annual Meeting of the Hawaiian Chemists' Association, Oct. 30, 1918.

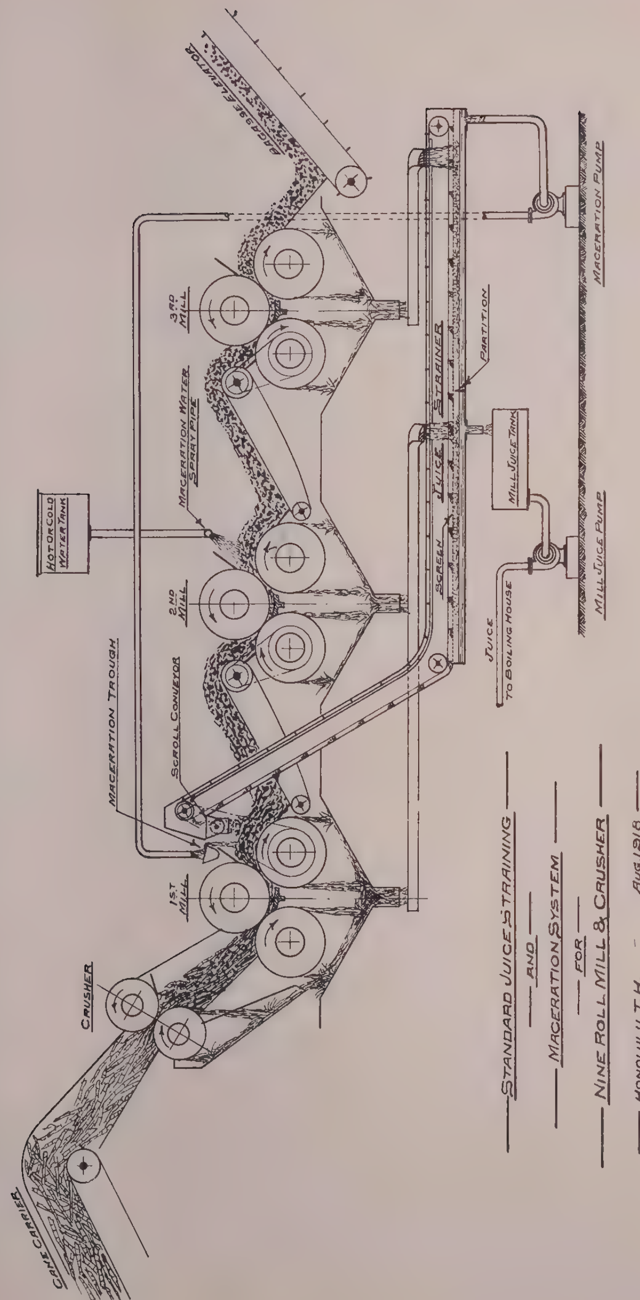

CANE CARRIER
CRUSHER
1ST. MILL
MACERATION TROUGH
SCROLL CONVEYOR
2ND MILL
HOT OR COLD WATER TANK
MACERATION WATER SPRAY PIPE
3RD MILL
BAGASSE ELEVATOR
SCREEN
JUICE STRAINER
PARTITION
MILL JUICE TANK
JUICE TO BOILING HOUSE
MILL JUICE PUMP
MACERATION PUMP
STANDARD JUICE STRAINING
AND
MACERATION SYSTEM
FOR
NINE ROLL MILL & CRUSHER
HONOLULU, T.H. AUG. 1918

Fig. 1.

cable, or up to that point where any further extraction would cease to be commercially profitable.

Various means have been resorted to for increasing extraction, among which may be mentioned the following: increasing the number of mills in a train; increasing the amount of maceration or imbibition water; and more lately by the installation of shredders and revolving cane knives.

Shredders prepare the cane for milling by a beating or disintegrating action, while revolving knives cut or slice the cane into more or less fine chips, during which preparatory processes large amounts of very finely-divided fibrous and pithy cane matter, technically called "cush-cush," is formed. Since this cush-cush or trash is carried along with the juice extracted from the cane by the mills, some means such as mechanical juice strainers must be provided for separating it from the mill juices previous to clarification.

Juice strainers such as are generally used in cane milling consist of a long narrow trough, the top side of which is closed with a very fine meshed screen through which the juice passes, while the finer fibrous particles of cane are retained on the top side of the screen, from which they are continuously removed by wooden slats attached at short intervals to an endless chain or chains, as shown in Fig. 1.

This sketch, which illustrates a typical arrangement of juice-straining apparatus, also shows how the maceration water is applied, and the thinner juice from the final mill or mills is returned to the first or previous mills for maceration on these mills, a system always adopted in high-class milling practice in order to obtain as high an extraction as possible.

Referring to Fig. 1 it will be noted that the juice from the last, or third, mill, thoroughly combined with the maceration water applied through the spray pipe after the second mill, is strained in the juice strainer, one half of which is partitioned off for this purpose, while the separated cush-cush or trash is conveyed, together with that separated from the juices from the previous mill and crusher, by the carrier slats and elevated to a scroll conveyor, which in turn distributes it more or less evenly throughout the width of the blanket of crushed cane or bagasse leaving the first mill.

This arrangement of juice straining, while it served its purpose in conjunction with six and nine-roller mills, is seriously handicapped when applied to twelve and fifteen-roller mills; more especially is this so when the mill rollers are grooved with Messchaert grooves, the function of which is to facilitate the feeding of the mills. These grooves must be kept open and

free from cush-cush, for which purpose steel fingers are provided, which, fitting into the individual grooves, continually scrape the trash from same and allow it to drop into the mill juice pan to be washed away with the expressed juice on its way to the strainer.

A further objection, and a serious one, is due to the fact that it is a difficult matter to entirely prevent the breaking of these juice groove cleaning fingers, owing to foreign matter entering the mills with the cane, in which case the broken parts drop into the mill juice pan, and after being carried along with the juice enter the strainer and, forming an obstruction to the carrier slats, invariably damage the juice screen to such an extent that it is necessary to stop milling operations in order to make the necessary repairs, resulting in unnecessary and costly delays.

Another objection to the present type of juice strainers is their cumbersome length when applied to twelve and fifteen-roller mills, which greatly adds to the difficulty of keeping them in repair.

The final and perhaps the most important objection to juice strainers as now constructed is their uncleanliness, for, due to the presence of numerous pockets, corners, ledges, etc., incident to the present design of strainers, ample opportunity is present for juice-soaked trash to gather and lodge therein, which trash rapidly sours and in so doing contaminates, so to speak, the purer juices coming in contact with same.

The present or standard system of juice straining has been described at some length and detail to show its disadvantages and how it is intended to improve same by substituting what may be called a "direct" system, shown in general arrangement in Fig. 2. In this system one small strainer or screen is used in such a position that it is readily and easily accessible for repairs and inspection at all times, and due to the method of operation and design is self-cleaning. The danger of juice souring is entirely eliminated, as it is impossible for cush-cush to lodge or collect in any part of the apparatus.

In operation this system, although accomplishing the same results as the old or standard system, but in a more direct, simple and less expensive manner, may be described as follows:

Maceration water, hot or cold, is applied through the spray pipe to the bagasse leaving the mill next to the last mill in the train (in this case the second mill), and after mixing with and being to an extent absorbed by this bagasse is extracted therefrom together with the remaining juice in the bagasse, by the final or last mill (in this case the third mill). This extracted juice being of a lower gravity due to the admixture of the

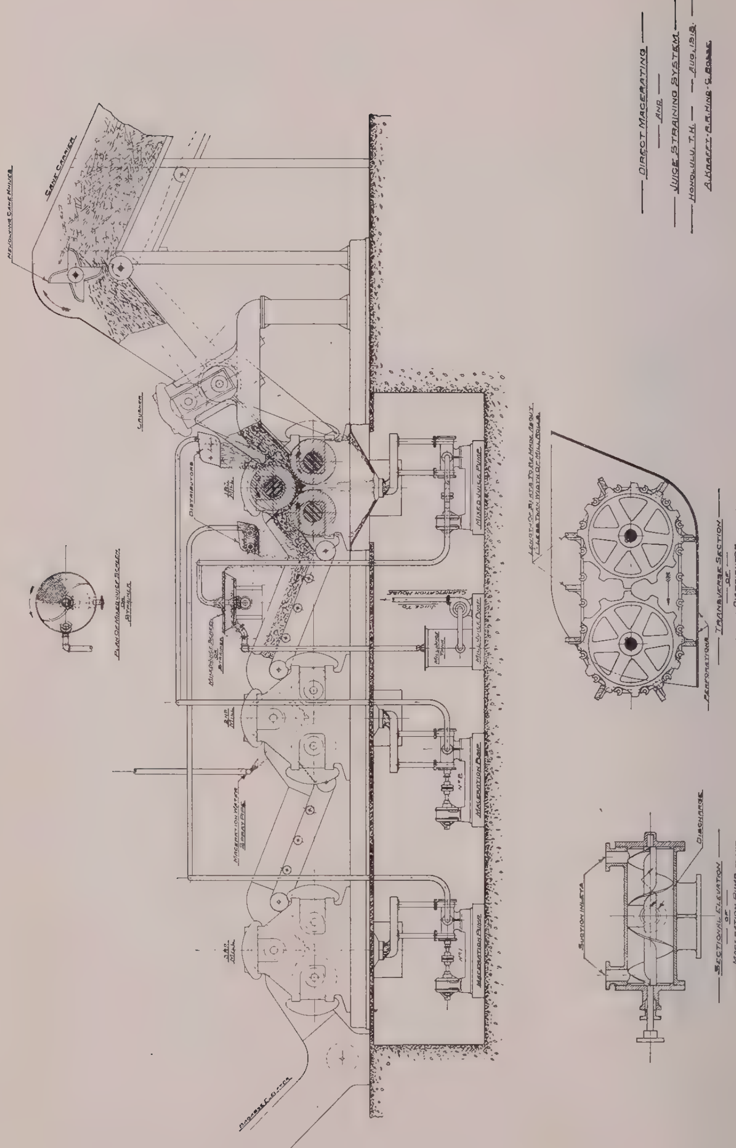

DIRECT MACERATING
AND
JUICE STRAINING SYSTEM
HONOLULU, T.H.
AUG, 1918
CANE CARRIER
CRUSHER
DISTRIBUTORS
1ST MILL
2ND MILL
3RD MILL
MIXED JUICE PUMP
MACERATION PUMP
TRANSVERSE SECTION
OF
DISTRIBUTOR
PERFORATIONS
SECTIONAL ELEVATION
OF
MACERATION PUMP
SUCTION INLETS
DISCHARGE

Fig. 2.

maceration water than any of the previous mills, is collected in the juice pan of the third mill, from which it runs by gravity to the maceration pump No. 1, which in turn forces the juice to the distributor placed on the discharge side of the first mill, where it performs the same function when mixed with the bagasse from this mill, as did the maceration water applied to the second mill.

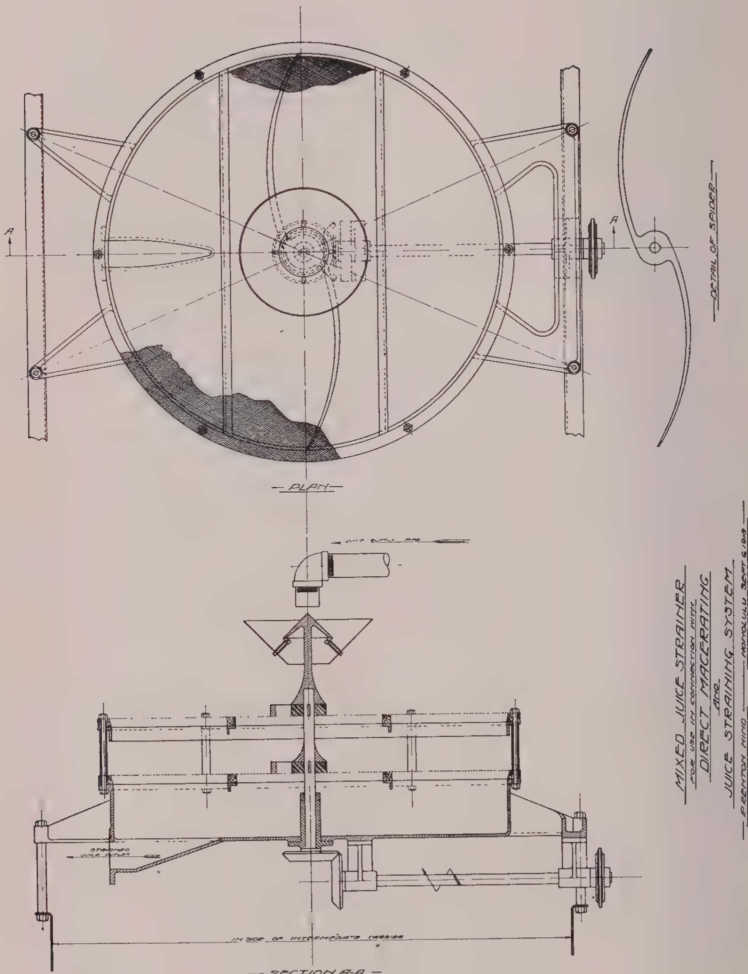
The juice from the second mill is collected in the second mill juice pan, from which it runs by gravity to the maceration pump No. 2, and thence pumped to the distributor placed on the discharge side of the crusher, where it acts as maceration for the bagasse leaving the crusher on the way to the first mill.

This, then, is the maceration system generally used, no matter how many mills may constitute a train, the juice expressed from a previous mill always being returned as maceration for the bagasse entering the preceding mill. The juice extracted by the crusher, together with that expressed by the first mill, mixes together in the juice pan of the first mill and is pumped by the mixed juice pump to the mixed juice strainer (shown in detail in Fig. 3), located over the carrier between the first and second mills, where the juice, after being separated from all entrained cush-cush or trash, is run to the usual mill juice storage tank, from which it is pumped by the mill juice pump to the clarification house.

It will be noted that in this direct system of maceration three novel and new features have been incorporated, viz: First, a balanced screw pump; second, a mechanically operated distributor; third, a circular mixed juice screen, a description of which follows:

The balanced screw pump, shown in section in Fig. 1, consists of a body on each end of which is located a suction inlet, and in which body a right and left-hand screw or scroll is arranged to revolve, thus forcing the entering juice towards the center of the pump, where it is discharged through the outlet or discharge nozzle. This pump, due to the absence of valves, cored passages, etc., is admirably adapted to the handling of liquids containing gritty or suspended matter, especially mill juices containing large quantities of earthy matter, cush-cush, etc., and for this reason the necessity of screening the juices previous to entering the pump is entirely eliminated. This latter is an important point, and it is principally due to this feature that the present system of juice straining and maceration is simplified and made possible to operate more directly and without the necessity of screening the juices before entering the pumping units of the system.

The mechanically-operated distributor, also shown in Fig. 2,


PLAN
SECTION A-A
DETAIL OF SPIDER
MIXED JUICE STRAINER
FOR USE IN CONNECTION WITH
DIRECT MACERATING
AND
JUICE STRAINING SYSTEM

is more or less self-explanatory, and is made up of two shafts to which are keyed on each end of same sprocket wheels of equal diameters. These shafts are arranged to run in an open steel casing with ends to which the shaft bearings are attached, the bottom part of the casing being perforated as shown. In operation, the juice containing large quantities of cush-cush enters the apparatus at the back side and opposite the open side, and, spreading over the length of the casing, is carried towards the open side by wooden slats attached at intervals to two sprocket chains belted over the sprocket wheels before mentioned. This arrangement serves to distribute both the maceration juice and contained cush-cush evenly over the bagasse, and does so in a much more satisfactory manner than any arrangement for the purpose heretofore used.

The circular mixed juice screen consists of one, two, or more circular screens, one arranged above the other as shown in Fig. 3, and operates as follows: The mixed juice containing large quantities of cush-cush flows onto the top screen through the center distributing funnels, where it is caught by the revolving spider, which gradually works the separated cush-cush to the outer edge of the circular screen, from which it falls and is distributed equally on the bagasse in the carrier between the first and second mills and on which it is supported. Any cush-cush contained in the juice flowing through the top screen is separated therefrom on the lower screen in a similar manner to that of the upper screen, the lower screen being provided with a revolving spider for the same purpose as the upper-screen spider. The juice after passing through the screens and thus being freed from all mechanical matter, cush-cush, etc., is caught in the bowl forming the lower part of the apparatus, from which it is piped to the mill juice-storage tank, and thence to the clarification house by the mill juice pump as shown in Fig. 2.

ANNUAL SYNOPSIS OF MILL DATA, 1918

By R. S. Norris.

Thirty-eight plantations sent in reports this season. Three of the smaller plantations belonging to the Association failed to report their factory results.

The large tables which form the basis of this report, have been rearranged this season. The plantations have previously been listed in the order of the length of the trains of mills. It seems more logical to place them in the order of their size, which is here determined from the averages of the last five crops. In comparing the results from different factories it is most natural to group them according to the size of the plantations and the present arrangement facilitates such comparisons. The columns have also been rearranged in an order which appears more logical. One new item has been added to the first table. The total weight of sugar reported is given in thousand tons, under the heading "Commercial Sugar."

In the milling machinery table full data covering the juice grooves are given for the first time. To do this it was necessary to print these data on a separate sheet. The importance of the juice grooves warrants this addition.

Varieties of Cane Ground.

The percentages of the different varieties of cane ground on each plantation are given in the table below. By comparing this table with that of last year, it will be seen that the varieties D 1135 and H 109 are increasing at the expense, principally, of Lahaina. From the standpoint of the factory work alone it is unfortunate that D 1135 has to be substituted for Lahaina. It is much less satisfactory for milling and also for the boiling-house work. H 109, on the other hand, so far as experience yet goes with it, is an excellent cane for the factory.

The averages for the different canes ground are given for the first time.

CANE MILL DATA, SEASON OF 1918 (CONTINUED)

ROLLER GROOVING

Factory	Factory No.	Milling Plant	Surface Grooves per Inch. Top, Front, Back. Crusher	1st Mill	2nd Mill	3rd Mill	4th Mill	5th Mill	6th Mill	7th Mill
H. C. & S. Co.	6	K(2),2RC78,S72,12RM78	—— ——	1 1/3, 1 1/3, 1 1/3	4, 8, 8	4, 8, 8	4, 8, 8	....	....	....
"	6	K(2),2RC78,S72,12RM78	—— ——	1 1/3, 1 1/3, 1 1/3	4, 8, 8	4, 8, 8	4, 8, 8	....	....	....
Maui Agr.	21	K(2),21RM66	....	1 1/2, 1 1/2, 1 1/2	6, 6, 6	6, 6, 6	6, 6, 6	6, 6, 6	6, 6, 6	6, 6, 6
Oahu	20	K(2),S72,14RM78	....	4, 3, 4	2 1/2, 2 1/2, 2 1/2	2 1/2, 2 1/2, 2 1/2	2 1/2, 2 1/2, 2 1/2	2 1/2, 2 1/2, 2 1/2	....	....
"	20	K(2),12RM78	....	2 2/3, 2/3	2 1/2, 2 1/2, 2 1/2	2 1/2, 2 1/2, 0	7, 7, 7	....	....	....
Ewa	5	K(2),20RM78	....	—— ——	2 2/3, 1 1/3, 1 3/5	2 2/3, 1 1/3, 2 2/3	2 2/3, 1 1/3, 2 2/3	2 2/3, 1, 2 2/3	2 2/3, 1 1/3, 2 2/3	2 2/3, 1 1/3, 2 2/3
Pioneer	10	K,2RC54,S54,12RM72	—— ——	7, 7, 7	7, 7, 7	7, 7, 7	7, 7, 7	....	....	....
Waialua	17	K(2),14RM78	....	4 5, 4 5	1 1/3, 1 1/3, 1 1/3	2 2/3, 2 2/3, 2 2/3	2 2/3, 2 2/3, 2 2/3	2 2/3, 2 2/3, 2 2/3	....	....
Haw. Sug.	16	K,2RC72,S72,12RM78	—— ——	4, 4, 4	4, 4, 4	4, 4, 4	4, 4, 4	....	....	....
Olaa	36	K,S72,12RM78	....	2, 6, 6	6, 6, 6	6, 6, 6	6, 6, 6	....	....	....
Honolulu	13	K(2),S54,11RM78	....	2 2/3, 2/3	1 1/3, 3, 1 1/3	6, 3, 6	6, 3, 6	....	....	....
Onomea	34	2RC60,S54,12RM66	—— ——	7, 2, 7	7, 4, 7	7, 4, 7	7, 7, 7	....	....	....
Hakalau	7	2RC54,12RM9-60,3-66	—— ——	5, 5, 5	7, 7, 7	7, 7, 7	7, 7, 7	....	....	....
Kekaha	25	2RC54,9RM60	—— ——	7, 1, 7	7, 7, 7	7, 7, 7	....	....	....	....
Hilo	33	K,2RC60,12RM66	—— ——	2 1/2, 5, 5	5, 5, 5	5, 5, 5	5, 5, 5	....	....	....
Wailuku	2	K,2RC72,12RM78	—— ——	4, 2 1/2, 1 1/4	4, 4, 4	4, 4, 4	4, 4, 4	....	....	....
McBryde	12	K,S54,9RM84	....	6, 6, 6	6, 6, 6	6, 6, 6	....	....	....	....
Honokaa	35	K(2),2RC60,12RM66	—— ——	2 2/3, 2 2/3, 2 2/3	5, 2 1/2, 5	7, 5, 5	7, 5, 7	....	....	....
Waiakea	3	K,S42,11RM60	....	—— ——	4, 4, 4	4, 4, 4	4, 4, 4	....	....	....
Haw. Agr.	30	3RC60,12RM66	2/3, 2/3, 2/3	2, 5, 2	5, 5, 5	5, 5, 5	5, 4, 5	....	....	....
Lihue	27	K,2RC72,12RM78	—— ——	2 2/3, 2 2/3, 5	5, 4, 5	5, 5, 0	5, 5, 0	....	....	....
Lihue, Han.	46	K,2RC72,9RM78	—— ——	6, 2, 0	7, 3 1/2, 0	5, 3 1/2, 0	....	....	....	....
Laupahoehoe	41	K(2),2RC60,9RM9-54,6-60	2/3, 2/3	2, 2, 2	6, 5, 6	6, 5, 6	....	....	....	....
Makee	14	K(2),9RM72	....	1, 3, 1	1, 7, 1	3, 7, 7	....	....	....	....
Pepeekeo	19	2RC54,9RM60	—— ——	5, 7, 0	5, 5, 0	5, 7, 0	....	....	....	....
Paauhau	24	2RC60,12RM66	—— ——	4, 4, 4	7, 7, 7	7, 7, 7	7, 7, 7	....	....	....
Kahuku	43	3RC60,S54,9RM72	—— ——	4, 4, 7	7, 7, 7	7, 7, 7	....	....	....	....
Hawi	26	K,3RC48,12RM3-48,9-54	—, 1, 3 1/2	3, 3 1/2, 3 1/2	3, 3, 3	3, 1, 3	3 1/2, 1 1/3, 3 1/2	....	....	....
"	26	K(2),S42,9RM54	....	3 1/2, 1, 2	3 1/2, 1 3/5, 4	4, 1 1/3, 3 1/2	....	....	....	....
Honomu	37	2RC60,9RM60	2/3, 2/3	5, 5, 0	6, 5, 0	5, 5, 5	....	....	....	....
Koloa	38	K,2RC60,12RM66	—— ——	5 1/3, 2 1/3, 5 1/3	5 1/3, 2 2/3, 5 1/3	5 1/3, 2 2/3, 5 1/3	5 1/3, 2 2/3, 5 1/3	....	....	....
Hutchinson	31	2RC60,9RM60	—— ——	5, 5, 5	5, 5, 5	5, 5, 5	....	....	....	....
Kaiwiki	32	K(2),2RC60,9RM60	—— ——	3, 3, 6	6, 3, 6	6, 3, 6	....	....	....	....
Kaeleku	47	K(2),2RC54,9RM60	—— ——	3, 5, 3	5, 5, 0	5, 5, 0	....	....	....	....
Kilauea	23	K,S,3RC60,9RM60	8/9, 8/9, 8/9	4, 4, 0	7, 4, 0	7, 4, 0	....	....	....	....
Kohala	40	K(2),S42,11RM60	....	—— ——	3 1/2, 3 1/2, 3 1/2	3 1/2, 4 1/2, 4 1/2	5, 5, 5	....	....	....
Waianae	9	12RM60	....	5, 7, 7	7, 7, 7	7, 7, 7	7, 7, 7	....	....	....
Waimanalo	1	K,8RM6-54,2-60	....	3, 2, 3	4, 4, 4	4, 4	....	....	....	....
Halawa	29	K,2RC60,6RM3-50,3-54	4, 4	4, 4, 4	4, 4, 4	....	....	....	....	....
Waimea	4	2RC48,12RM42	—— ——	8/9, 8/9, 8/9	4, 4, 8	8, 4, 8	8, 4, 8	....	....	....
Kipahulu	44	K,5RM3-42,2-54	....	5, 2, 5	5, 5	....	....	....	....	....

JUICE GROOVES

Factory	Factory No.	1st Mill Front Width	Depth	Pitch	1st Mill Back Width	Depth	Pitch	2nd Mill Front Width	Depth	Pitch	2nd Mill Back Width	Depth	Pitch	3rd Mill Front Width	Depth	Pitch	3rd Mill Back Width	Depth	Pitch
H. C. & S. Co.	6	—	—	—	—	—	—	1/4	2	4	1/4	2	4	1/4	2	4	1/4	2	4
"	6	—	—	—	—	—	—	1/4	2	4	1/4	2	4	1/4	2	4	1/4	2	4
Maui Agr.	21	—	—	—	—	—	—	5/16	1 1/2	3	5/16	1 1/2	3	5/16	1 1/2	3	5/16	1 1/2	3
Oahu	20	—	—	—	....	....	....	5/16	2	3 1/2	5/16	2	3 1/2	5/16	2	3 1/2	5/16	2	3 1/3
"	20	1/2	2	3	—	—	—	1/2	2	2 1/2	5/16	2	4	5/16	2	3 1/2	3/16	1/2	1
Ewa	5	—	—	—	....	....	—	—	—	—	—	—	—	1/4	1 1/4	4	—	—	—
Pioneer	10	3/16	1 5/8	4	3/16	1 5/8	4	3/16	1 5/8	4	3/16	1 5/8	4	3/16	1 5/8	4	3/16	1 5/8	4
Waialua	17	—	—	—	....	....	....	1/8	1 3/4	3	1/8	1 3/4	4 1/2	3/8	1 1/2	1 7/8	3/8	1 1/2	1 7/8
Haw. Sug.	16	1/4	1 1/4	2	1/4	1 1/4	2	1/4	1 1/4	2	1/4	1 1/4	2	1/4	1 1/4	2	1/4	1 1/4	2
Olaa	36	1/4	1 1/2	3	—	—	—	1/4	1 1/2	3	—	—	—	1/4	1 1/2	3	—	—	—
Honolulu	13	—	—	—	....	....	....	5/16	1 1/4	1 1/2	—	—	—	3/8	1 1/4	3	3/16	1 1/4	4
Onomea	34	1/4	1 1/2	2	5/32	1 1/4	2	1/4	1 1/2	2	5/32	1 1/4	2	1/4	1 1/2	2	5/32	1 1/4	2
Hakalau	7	5/16	1 1/2	4	1/4	1 1/2	2	1/4	1 1/2	4	1/8	1 1/2	2	1/4	1 1/2	2	1/8	1 1/2	2
Kekaha	25	—	—	—	5/16	1 1/4	1 1/2	1/4	1 1/4	2 1/2	3/16	1 1/4	2	1/4	1 1/4	2 1/2	1/8	1 1/4	2
Hilo	33	1/4	1 1/2	3	1/8	1 1/4	1 3/5	1/4	1 1/2	3	1/8	1 1/4	1 3/5	1/4	1 1/2	3	1/8	1 1/4	1 3/5
Wailuku	2	3/8	2	3 5/8	—	—	—	3/8	2	4	1/4	2	2	3/8	2	4	1/4	2	2
McBryde	12	3/8	1 5/16	3	5/16	1 1/8	2 1/4	3/8	1 1/2	3	1/4	1 1/4	2 1/4	5/16	1 3/8	3	1/4	1 1/4	2 1/4
Honokaa	35	5/16	1 1/2	2	—	—	—	5/16	1 1/2	2	3/16	1 1/2	2	1/4	1 1/2	2	5/32	1 1/2	2
Waiakea	3	—	—	—	....	....	....	1/4	1 1/2	3	3/16	1 1/2	2	3/8	1 1/2	3 1/2	3/16	1 1/2	2
Haw. Agr.	30	3/16	1 1/2	2	—	—	—	3/16	1 1/2	2	1/8	1 1/2	2	3/16	1 1/2	2	1/8	1 1/2	2
Lihue	27	—	—	—	1/8	1 1/4	2 1/4	1/4	1 1/4	2 3/4	1/8	1 1/4	2 1/2	1/4	1 1/4	2 1/2	1/8	1 1/4	2 1/2
Lihue, Han.	46	1/4	1 1/4	2 1/2	1/8	1	2	1/4	1 1/4	2 1/2	1/8	1	2	1/4	1 1/4	2 1/2	1/8	1	2
Laupahoehoe	41	—	—	—	—	—	—	1/4	1 1/4	2 1/2	1/8	1	2	1/4	1 1/2	2 1/2	1/8	1	2
Makee	14	3/8	5/8	3	—	—	—	3/8	1 1/4	4	—	—	—	1/4	1 1/8	3	3/16	1	2
Pepeekeo	19	1/4	1 1/4	3	1/8	1 1/2	1 1/2	1/4	1 1/4	3	1/8	1 1/2	1 1/2	1/4	1 1/4	3	1/8	1 3/4	1 1/2
Paauhau	24	9/32	1 1/2	3	9/64	1 1/2	1/2	9/32	1 1/2	3 1/2	9/64	1 1/4	2	9/32	1 1/2	3 1/2	9/64	1 3/8	1 1/2
Kahuku	43	1/4	1 1/2	4 5/8	—	—	—	1/4	1 1/2	4 5/8	—	—	—	1/4	1 1/2	4 5/8	....	....	....
Hawi	26	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
"	26	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1/4	1 1/2	2 3/4
Honomu	37	1/4	1 1/2	3	1/8	1 1/2	2	1/4	1 1/2	3	1/8	1 1/2	1 1/2	1/4	1 1/2	3	1/8	1 1/2	2
Koloa	38	1/4	1 1/8	2 5/8	1/8	1	2 5/8	1/4	1 1/8	2 5/8	1/8	1	2 5/8	1/4	1 1/8	2 5/8	1/8	1	2 5/8
Hutchinson	31	1/4	1 1/2	3	1/8	1 1/2	2	1/4	1 1/2	3	1/8	1 1/2	2	1/8	1 1/2	2	1/8	1 1/2	2
Kaiwiki	32	3/8	1 1/4	2 3/4	—	—	—	3/8	1 1/4	2 3/4	—	—	—	3/8	1 1/4	2 3/4	3/16	1 1/4	2 3/8
Kaeleku	47	1/4	1 1/2	2	1/8	1 1/2	2	1/4	1 1/2	2	1/8	1 1/2	2	1/4	1 1/2	3	1/8	1 1/2	2
Kilauea	23	1/2	1 1/4	3	3/16	1 1/4	2	1/2	1 1/4	3	3/16	1 1/2	2	1/2	1 1/4	3	3/16	1 1/4	2
Kohala	40	—	—	—	....	....	....	1/4	1 1/4	2 1/2	1/4	1 1/4	3	1/4	1 1/4	3	1/4	1 1/4	3
Waianae	9	—	—	—	—	—	—	—	—	—	—	—	—	1/4	1 1/4	2 1/2	—	—	—
Waimanalo	1	—	—	—	—	—	—	—	—	—	—	—	—	1/2	7/8	3	....	....	....
Halawa	29	—	—	—	—	—	—	—	—	—	—	—	—	....	....	....	....	....	....
Waimea	4	—	—	—	—	—	—	1/4	1	2	1/8	1	2	1/4	1	2	1/8	1	2
Kipahulu	44	—	—	—	3/16	1 1/4	1	3/16	1	1 3/4	....	....	....	....	....	....	....	....	....

Factory	Factory No.	4th Mill Front Width	Depth	Pitch	4th Mill Back Width	Depth	Pitch	5th Mill Front Width	Depth	Pitch	5th Mill Back Width	Depth	Pitch	6th Mill Front Width	Depth	Pitch	6th Mill Back Width	Depth	Pitch	7th Mill Front Width	Depth	Pitch	7th Mill Back Width	Depth
H. C. & S. Co.	6	1/4	2	4	1/4	2	4	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
"	6	1/4	2	4	1/4	2	4	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Maui Agr.	21	5/16	1 1/2	3	5/16	1 1/2	3	5/16	1 1/2	3	5/16	1 1/2	3	....	....	....	5/16	1 1/2	3	5/16	1 1/2	3	5/16	1 1/2
Oahu	20	5/16	2	3 1/2	5/16	2	3 1/2	5/16	2	3 1/2	5/16	2	3 1/2	5/16	1 1/2	[illegible]	....	....	....	....	....	....	....	....
"	20	5/16	2	3 1/2	5/16	2	4	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Ewa	5	1/4	1 1/4	4	1/8	1 1/4	4	....	....	....	1/8	1 1/4	4	....	....	....	1/8	1 1/4	4	1/4	1 1/4	4	1/8	1 1/4
Pioneer	10	3/16	1 5/8	4	3/16	1 5/8	4	....	....	....	....	....	....	1/4	1 1/4	4	....	....	....	....	....	....	....	....
Waialua	17	3/8	1 1/2	2 1/4	3/16	1 1/2	2	3/8	1 1/2	2 1/2	1/4	1 1/2	2	....	....	....	....	....	....	....	....	....	....	....
Haw. Sug.	16	1/4	1 1/4	2	1/4	1 1/4	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Olaa	36	1/4	1 1/2	3	1/4	1 1/2	3	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Honolulu	13	9/16	1 1/4	3	3/16	1 1/4	4	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Onomea	34	1/4	1 1/2	2	5/32	1 1/4	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Hakalau	7	1/4	1 1/2	2	3/16	1 1/2	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Kekaha	25	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Hilo	33	1/4	1 1/2	3	1/8	1 1/3	1 3/5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Wailuku	2	3/8	2	4	1/4	2	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
McBryde	12	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Honokaa	35	1/4	1 1/2	2	5/32	1 1/2	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Waiakea	3	3/8	1 1/2	3 1/2	3/16	1 1/2	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Haw. Agr.	30	1/4	1 1/2	2	3/16	1 1/2	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Lihue	27	1/8	1 1/4	3	1/8	1	2 1/2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Lihue, Han.	46	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Laupahoehoe	41	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Makee	14	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pepeekeo	19	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Paauhau	24	9/32	1 1/2	3	9/64	1 1/4	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Kahuku	43	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Hawi	26	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
"	26	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Honomu	37	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Koloa	38	1/4	1 1/8	2 5/8	1/8	1	2 5/8	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Hutchinson	31	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Kaiwiki	32	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Kaeleku	47	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Kilauea	23	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Kohala	40	1/4	2	3	1/4	2	3	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Waianae	9	1/4	1 1/4	2 3/8	1/8	1 1/4	3	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Waimanalo	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Halawa	29	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Waimea	4	1/4	1	2	1/8	1	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Kipahulu	44	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

CANE MILL DATA, SEASON OF 1918

…on	Factory No.	MILLING PLANT (Sizes in Inches)	Revolving Knives, First Set: Number	First Set: Distance Apart, Inches	First Set: Distance from Conveyor, Inches	First Set: Revolutions per Minute	Second Set: Number	Second Set: Distance Apart, Inches	Second Set: Distance from Conveyor, Inches	Second Set: Revolutions per Minute
Co..	6	K(2),2RC34x78,S72,12RM34x78	28	9	28	1200	48	6 1/2	17	1200
		K(2),2RC34x78,S72,12RM34x78	28	9	28	1200	48	6 1/2	17	1200
....	21	K(2),21RM34x66	72	7/8	10	450	72	7/8	7/8	[illegible]
....	20	K(2),S72,14RM2 33x78,12-34x78	26	4	24	490	54	2	4	690
		K(2),12RM34x78	11	7	30	290	52	2	3	690
....	5	K(2),20RM2 32x78,18 34x78	12	6	12	350	80	7/8	1 1/2	500
....	10	K,2RC24x54,S54,12RM34x72	13	4	3	535	..	....	....	....
....	17	K(2)14RM2-32x78,12 34x78	38	3 1/2	12	560	88	3	1	560
....	16	K,2RC28x72,S72,12RM34x78	38	3 1/2	11	350	..	....	....	....
....	36	KS72,12RM34x78	44	1 5/8	5	450	..	....	....	....
....	13	K(2),S54,11RM34x78	24	6	18	450	24	6	4	500
....	34	2RC24x60,S54,12RM32x66	..	....	....	....	..	....	....	....
....	7	2RC,24x54,12RM9 32x60,3-32x66	..	....	....	....	..	....	....	....
....	25	2RC24x54,9RM32x60	..	....	....	....	..	....	....	....
....	33	K,2RC24x60,12RM32x66	10	6	8	275	..	....	....	....
....	2	K,2RC24x72,12RM34x78	12	5 1/2	3 1/2	400	..	....	....	....
....	12	K,S54,9RM34x84	18	8	4	450	..	....	....	....
....	35	K(2),2RC30x60,12RM32x66	14	4	16	350	68	1 3/4	1 1/4	450
....	3	K,S42,11RM2-30x60,9 32x60	14	4	1	375	..	....	....	....
....	30	3RC32x60,12RM32x66	..	....	....	....	..	....	....	....
....	27	K,2RC26x72,12RM34x78	10	6	12	240	..	....	....	....
....	46	K,2RC26x72,9RM34x78	11	6 1/4	10	285	..	....	....	....
…oe..	41	K(2),2RC30x60,9RM3-30x54,6-32x60	16	3 1/2	3/4	450	48	1 3/8	1/2	400
....	14	K(2),9RM34x72	12	6	12	300	80	7/8	2	500
....	19	2RC24x54,9RM6-32x60,3 30x60	..	....	....	....	..	....	....	....
....	24	2RC24x60,12RM32x66	..	....	....	....	..	....	....	....
....	43	3RC30x60,S54,9RM34x72	..	....	....	....	..	....	....	....
....	26	K,3RC26x48,12RM3 26x48,9-30x54	8	5	2	400	..	....	....	....
		K(2),S42,9RM30x54	8	6 3/4	3	360	18	6	3/4	345
....	37	2RC30x60,9RM32x60	..	....	....	....	..	....	....	....
....	38	K,2RC24x60,12RM32x66	12	5	9	300	..	....	....	....
....	31	2RC30x60,9RM32x60	..	....	....	....	..	....	....	....
....	32	K(2),2RC26x60 9RM32x60	16	3	3	375	40	3 1/2	1 1/2	400
....	47	K(2),2RC24x54,9RM32x60	9	6	8	250	36	1 1/2	2	400
....	23	K,S,3RC32x60,9RM32x60	10	5 1/2	2	280	..	....	....	....
....	40	K(2),S42,11RM2-30x60,9 32x60	12	4 1/2	18	300	40	1 1/2	1 1/2	475
....	9	12RM9-30x60,3-32x60	..	....	....	....	..	....	....	....
....	1	K,8RM6 26x54,2-30x60	8	6	8	....	..	....	....	....
....	29	K,2RC30x60,6RM3 25x50,3-26x54	20	2 1/2	4	375	..	....	....	....
....	4	2RC24x48,12RM26x42	..	....	....	....	..	....	....	....
....	44	K,5RM3 22x42,2-25x54	16	4	2	300	..	....	....	....

MILL OPENINGS—INCHES

Factory No.	Crusher	1st Mill Front	1st Mill Back	2nd Mill Front	2nd Mill Back	3rd Mill Front	3rd Mill Back	4th Mill Front	4th Mill Back	5th Mill Front	5th Mill Back
6	1/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
36	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
34	1/2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	1/4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	1/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
33	3/16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
35	1/4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	5/8x1/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	1/16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
46	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
41	5/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	1/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	1/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
43	5/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	11/16x0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
37	3/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
38	7/16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	3/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
32	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
47	1/2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	1/4x1/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
40	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	1/4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
44	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

RETURNER BAR — DISTANCE FROM TOP ROLLER—INCHES

Factory No.	Crusher Toe	Crusher Center	Crusher Heel	1st Mill Toe	1st Mill Center	1st Mill Heel	2nd Mill Toe	2nd Mill Center	2nd Mill Heel	3rd Mill Toe	3rd Mill Center	3rd Mill Heel	4th Mill Toe	4th Mill Center	4th Mill Heel	5 th Mill Toe	5 th Mill Center	5 th Mill Heel
6	....	....	....	1 1/2	1 3/4	2	1 3/8	1 5/8	1 7/8	1 3/8	1 5/8	1 7/8	1 3/8	1 5/8	1 7/8	....	....	....
	....	....	....	1 1/2	1 3/4	2	1 3/8	1 5/8	1 7/8	1 3/8	1 5/8	1 7/8	1 3/8	1 5/8	1 7/8	....	....	....
21	....	....	....	....	1/2	....	....	1 1/2	....	....	1 1/2	....	....	1 3/8	....	....	1 1/2*	....
20	....	....	....	....	....	....	....	1 1/4	....	....	1 1/2	....	....	1 1/2	....	....	1 1/2	....
	....	....	....	....	1 3/4	....	....	1 1/2	....	....	1 1/2	....	....	1 1/2	....	....	....	....
5	....	....	....	....	....	....	1 3/4	2	2 1/4	1 3/4	2	2 1/4	1 3/4	2	2 1/4	1 3/4	2	2 1/4 †
10	....	....	....	1 1/2	....	2	1 1/4	....	1 3/4	1 1/4	....	1 3/4	1 1/4	....	1 1/2	....	....	....
17	....	....	....	....	....	....	5/8	3/4	1 3/4	5/8	3/4	1 3/4	9/16	11/16	1 1/4	9/16	11/16	1 1/4
16	....	....	....	1 1/2	1 3/4	2	1 3/8	1 5/8	1 7/8	1 1/4	1 1/2	1 3/4	1 1/8	1 3/8	1 5/8	....	....	....
36	....	....	....	1 1/4	1 1/2	1 3/4	1 1/8	1 1/4	1 1/2	3/4	1	1 1/4	3/4	1	1 1/4	....	....	....
13	....	....	....	....	....	....	2 1/8	2 1/8	2 3/8	1 1/4	1 1/4	1 5/8	1 1/2	1 1/2	1 5/8	....	....	....
34	....	....	....	1	1 1/2	1 3/4	1	1 1/2	1 3/4	1	1 1/4	1 1/2	1	1 1/4	1 1/2	....	....	....
7	....	....	....	5/8	3/4	1 1/2	1/4	5/8	1 5/8	1/4	5/8	1 3/8	1/4	5/8	1 3/8	....	....	....
25	....	....	....	1 3/4	2	2 1/2	1/4	1/2	2	7/8	1 1/8	1 3/4	....	....	....	....	....	....
33	....	....	....	11/16	1 11/16	1 31/32	1 5/16	1 1/2	1 21/32	1 3/16	1 1/2	1 7/8	15/16	1 5/16	1 3/8	....	....	....
2	....	....	....	2	2 1/8	2 1/4	2	2 1/4	2 1/2	1 1/2	1 13/16	2 1/8	1 1/2	1 15/16	2 1/8	....	....	....
12	....	....	....	1 1/2	1 13/16	2 5/16	1 3/8	1 1/2	1 7/8	1 1/8	1 5/16	1 3/4	....	....	....	....	....	....
35	....	....	....	7/8	1 1/2	1 3/4	3/4	1 1/4	1 1/2	3/4	1 1/4	1 1/2	3/4	1 1/4	1 1/2	....	....	....
3	....	....	....	....	....	....	1	1 1/4	2	1	1 1/4	2	1	1 1/4	2	....	....	....
30	1 3/8	1 1/2	1 5/8	1 3/4	1 3/4	1 3/4	1 1/2	1 1/2	1 3/4	1 3/8	1 3/8	1 5/8	1	1	1 1/4	....	....	....
27	....	....	....	1 1/4	1 1/2	1 7/8	1 1/8	1 3/8	1 3/4	3/4	1 3/16	1 1/2	5/8	1 1/8	1 5/8	....	....	....
46	....	....	....	1 1/4	1 1/2	2	1	1 1/4	1 3/4	3/4	1	1 1/4	....	....	....	....	....	....
41	....	....	....	1 1/2	....	....	1	....	....	3/4	....	....	....	....	....	....	....	....
14	....	....	....	1	1 1/4	1 1/2	1	1 1/4	1 1/2	1	1 1/4	1 1/2	....	....	....	....	....	....
19	....	....	....	1	1 1/8	1 1/4	3/4	1 1/16	1 7/8	15/16	1 1/8	2 1/8	....	....	....	....	....	....
24	....	....	....	1 5/8	1 7/8	2 1/8	1 13/16	1 7/8	2 1/8	1 11/16	1 3/4	2 1/8	1 1/8	1 3/8	2	....	....	....
43	....	....	....	1 1/8	1 1/2	2	3/4	1 1/8	2	1/2	3/4	1	....	....	....	....	....	....
26	1	1 1/4	1 1/4	3/4	1 1/4	1 1/4	3/4	1 1/4	1 1/2	3/4	1 1/8	1 1/4	3/4	1	1	....	....	....
	....	....	....	1	1 3/8	1 3/4	3/4	1 1/8	1 1/2	1/2	1	1 1/4	....	....	....	....	....	....
37	....	....	....	7/8	1 1/4	1 3/16	3/4	1	1 1/8	1/2	7/8	1	....	....	....	....	....	....
38	....	....	....	1	1 1/2	2	1	1 1/4	1 1/2	3/4	1	1 1/4	3/4	1	1 1/4	....	....	....
31	....	....	....	1 1/8	1 7/16	1 3/4	7/8	1 1/4	1 5/8	3/4	1	1 3/8	....	....	....	....	....	....
32	....	....	....	....	2	....	....	1 1/2	....	....	1 1/8	....	....	....	....	....	....	....
47	....	....	....	1	1 1/2	2	1	1 1/8	1 5/8	1/2	3/4	1 1/4	....	....	....	....	....	....
23	....	....	....	1 1/4	1 3/8	1 7/16	1 1/8	1 1/4	1 3/8	1 1/8	1 1/4	1 3/8	....	....	....	....	....	....
40	....	....	....	....	....	....	1 1/4	1 1/2	1 3/4	1	1 1/4	1 1/2	3/4	7/8	1 3/8	....	....	....
9	....	....	....	1	1 1/4	1 1/2	5/8	3/4	1 1/2	3/8	7/8	7/8	1/2	5/8	7/8	....	....	....
1	....	....	....	2	2 1/8	2 1/4	2	2 1/8	2 1/4	....	....	....	....	....	....	....	....	....
29	....	....	....	1	1 1/8	1 1/4	7/8	1 1/16	1 1/4	....	....	....	....	....	....	....	....	....
4	....	....	....	1 1/4	....	1 3/4	1 1/4	....	1 3/4	27/32	31/32	1 9/32	11/16	15/16	1 15/16	....	....	....
44	....	....	....	2 1/2	2 3/4	....	....	....	....	....	....	....	....	....	....	....	....	....

RETURNER BAR — WIDTH—INCHES; DISTANCE FROM BACK ROLLER—INCHES

Factory No.	Width 1st Mill	Width 2nd Mill	Width 3rd Mill	Width 4th Mill	Width 5th Mill	Width 6th Mill	Width 7th Mill	Back Roller 1st Mill	Back Roller 2nd Mill	Back Roller 3rd Mill	Back Roller 4th Mill	Back Roller 5th Mill	Back Roller 6th Mill	Back Roller 7th Mill
6	13	12 1/2	11 3/4	12 1/4	....	....	....	1/2	1/2	1/2	1/2	....	....	....
	13	12 1/2	11 3/4	12 1/4	....	....	....	1/2	1/2	1/2	1/2	....	....	....
21	....	....	....	....	....	....	....	....	1	3/4	1/2	3/4	1/2	1/2
20	....	15	15	15	15	....	....	....	1/2	1/2	1/2	1/2	....	....
	15	15	15	15	....	....	....	1/2	1/2	1/2	1/2	....	....	....
5	....	....	....	....	....	....	....	....	3/4	3/4	1/2	1/2	1/2	1/4
10	12	13	13	13	....	....	....	3/8	1/2	1/2	1/2	....	....	....
17	....	13 3/4	13 1/4	13 5/8	13 5/8	....	....	....	1/2	3/4	3/4	5/8	....	....
16	12 1/2	....	....	....	....	....	....	1/4	1/4	1/4	1/4	....	....	....
36	14	14	14	12	....	....	....	1/2	1/2	1/2	1/2	....	....	....
13	....	12	13 3/4	13	....	....	....	....	3/4	1/2	1/2	....	....	....
34	12 1/2	12 1/2	11	12 1/2	....	....	....	1/2	1/2	1/2	1/2	....	....	....
7	13	12 3/8	12 1/2	13	....	....	....	1/2	1/2	1/8	1/8	....	....	....
25	12	11	11	....	....	....	....	1/2	3/8	3/8	....	....	....	....
33	11 1/8	12	11 1/2	11 1/4	....	....	....	1/4	1/2	1/4	1/4	....	....	....
2	11	11 1/2	13 3/8	13 1/4	....	....	....	3/4	1	1 1/2	1	....	....	....
12	....	....	....	....	....	....	....	1 3/4	1 5/8	1 7/16	....	....	....	....
35	12	12	12	12	....	....	....	3/4	3/4	3/4	3/4	....	....	....
3	....	12	12	12	....	....	....	....	1/8	1/8	1/8	....	....	....
30	10 1/2	12	11 1/2	11	....	....	....	2	1	1	1/4	....	....	....
27	13 1/2	13 3/8	13 1/2	13 3/4	....	....	....	3/4	3/4	9/16	1/2	....	....	....
46	11	10 3/4	12 1/8	....	....	....	....	5/8	9/16	1/2	....	....	....	....
41	13	11 1/2	11 1/2	....	....	....	....	3/4	5/8	5/8	....	....	....	....
14	14	12	12	....	....	....	....	1 1/4	1	1	....	....	....	....
19	14 1/2	13 1/2	12 1/8	....	....	....	....	1/2	1/2	1/2	....	....	....	....
24	10 1/8	11 1/8	10	12 1/4	....	....	....	1/2	1	7/8	5/8	....	....	....
43	14	14 3/4	12 1/2	....	....	....	....	5/8	5/8	5/8	....	....	....	....
26	10 1/2	11 1/2	12	12	....	....	....	3/8	3/8	3/8	3/8	....	....	....
	11 1/2	11 1/2	12	....	....	....	....	1/2	3/8	3/8	....	....	....	....
37	11	11 1/4	11 1/2	....	....	....	....	1 1/4	1/2	5/8	....	....	....	....
38	12	12	12	12	....	....	....	1/4	1/4	1/4	1/4	....	....	....
31	11 3/4	12	12 1/2	....	....	....	....	1/2	1/2	1/2	....	....	....	....
32	12	12	12	....	....	....	....	5/8	3/8	3/8	....	....	....	....
47	14	12 1/2	14	....	....	....	....	3/4	3/4	1/2	....	....	....	....
23	11	11 1/2	11 1/2	....	....	....	....	1	3/8	3/8	....	....	....	....
40	....	9 1/2	11	12	....	....	....	....	3/4	1/2	3/8	....	....	....
9	12	12	12	12	....	....	....	1/2	1/2	1/2	1/2	....	....	....
1	....	....	....	....	....	....	....	3/4	3/8	....	....	....	....	....
29	12	12	....	....	....	....	....	1/2	3/8	....	....	....	....	....
4	9	11	10	10	....	....	....	1 1/4	1	3/4	3/4	....	....	....
44	....	....	....	....	....	....	....	....	....	....	....	....	....	....

SPEED OF ROLLERS—FEET PER MINUTE; PRESSURE ON ROLLERS—TONS

Factory No.	Speed: Crusher	Speed: 1st Mill	Speed: 2nd Mill	Speed: 3rd Mill	Speed: 4th Mill	Speed: 5th Mill	Speed: 6th Mill	Speed: 7th Mill	Pressure: Crusher	Pressure: 1st Mill	Pressure: 2nd Mill	Pressure: 3rd Mill	Pressure: 4th Mill	Pressure: 5th Mill	Pressure: 6th Mill	Pressure: 7th Mill	Tons Cane per Hour	Tonnage Ratio	Factory No.	Plantation
6	35.5	25	27.5	30	30	....	....	....	300	400	450	510	550	...	...	...	110.73	1.57	6	H. C. & S. Co.
	35.5	25	27.5	30	30	....	....	....	300	400	450	510	550	...	...	...				
21	....	23	25.5	25.2	28.8	23.5	25.3	28.8	...	450	540	350	486	260	330	380	57.54	1.62	21	Maui Agr.
20	....	30.6	26.6	25.6	29.3	30.1	....	....	...	252	462	481	431	431	...	...	77.14	1.88	20	Oahu
	....	19.7	17.6	20	20.7	....	....	....	...	382	523	366	339	...	...	...		2.02		
5	....	17.5	16.3	18.5	19.9	21.1	24.1	27.6	...	208	413	419	415	421	423	441	65.8	[illegible]	5	Ewa
10	51.4	34.4	26.9	29.6	34.1	....	....	....	...	440	330	330	350	...	...	...	57.68	1.92	10	Pioneer
17	....	22.6	21.1	18.5	21	22.5	....	....	...	324	[illegible]	430	420	430	...	...	54.7	1.55	17	Waialua
16	25.8	16	18.4	21.3	22.1	....	....	....	200	420	410	418	428	...	...	...	42.04	1.19	16	Haw. Sug.
36	....	19.7	21.6	24.7	28.4	....	....	....	...	350	500	300	460	...	...	...	53.7	1.91	36	Olaa
13	....	20.6	19.7	22.1	24.1	....	....	....	...	250	450	450	420	...	...	...	39.4	1.40	13	Honolulu
34	29.9	23.4	23.4	24.3	30.1	....	....	....	...	400	370	370	400	...	...	...	37.61	1.49	34	Onomea
7	....	20.3	23.7	25.9	22.9	....	....	....	...	322	322	345	380	...	...	...	31.26	1.50	7	Hakalau
25	....	14.6	16.7	18.8	....	....	....	....	...	331	349	360	...	...	...	...	30.74	1.84	25	Kekaha
33	28.6	19.6	22	23.6	18.3	....	....	....	...	395	390	390	430	...	...	...	34.74	1.38	33	Hilo
2	....	25	19	22	25	....	....	....	...	431	364	384	376	...	...	...	36.19	1.03	2	Wailuku
12	....	17.9	18.2	20.1	....	....	....	....	...	452	490	502	...	...	...	...	36.95	1.54	12	McBryde
35	23.4	16.8	22	24.7	27.5	....	....	....	...	380	430	430	430	...	...	...	36.89	1.46	35	Honokaa
3	....	....	17.9	19.9	22	....	....	....	...	175	340	340	340	...	...	...	27.0	1.42	3	Waiakea
30	21.3	19.7	20.3	22.5	24	....	....	....	350	370	360	390	470	...	...	...	43.37	1.72	30	Haw. Agr.
27	28	20	20	19.6	22	....	....	....	...	470	400	430	445	...	...	...	44.19	1.20	27	Lihue
46	16	16.7	19.2	21.8	....	....	....	....	...	435	420	420	...	...	...	...	34.92	1.34	46	Lihue, Han.
41	....	....	....	....	....	....	....	....	148	228	357	364	...	...	...	...	25.11	1.51	41	Laupahoehoe
14	....	15.5	17.7	21.5	....	....	....	....	...	400	425	415	...	...	...	...	38.29	2.13	14	Makee
19	....	17.9	19.7	21.6	....	....	....	....	...	375	375	375	...	...	...	...	25.20	1.51	19	Pepeekeo
24	28	17.2	18.7	25.8	22.8	....	....	....	...	383	369	332	374	...	...	...	28.01	1.51	24	Paauhau
43	....	....	....	....	....	....	....	....	160	440	310	406	...	...	...	...	24.16	1.01	43	Kahuku
26	20	21.5	17.5	18	18.5	....	....	....	148	144	280	280	275	...	...	...	24.11	1.94	26	Hawi
	....	17.5	18.5	18.5	....	....	....	....	...	280	280	272	...	...	...	...				
37	19	15.5	17.7	19.8	....	....	....	....	...	381	381	381	...	...	...	...	23.04	1.38	37	Honomu
38	....	16.6	18.3	15.1	16.7	....	....	....	...	400	400	400	400	...	...	...	31.90	1.34	38	Koloa
31	20.1	18.1	20.3	23.2	....	....	....	....	...	300	300	375	...	...	...	...	26.41	1.58	31	Hutchinson
32	....	16.1	17.9	19.9	....	....	....	....	...	311	288	296	...	...	...	...	22.32	1.34	32	Kaiwiki
47	....	16.3	17.1	19.4	....	....	....	....	...	329	346	354	...	...	...	...	25.10	1.51	47	Kaeleku
23	18	19	20	20	....	....	....	....	320	320	300	312	...	...	...	...	23.23	1.39	23	Kilauea
40	....	21	16	21	25	....	....	....	...	...	228	327	365	...	...	...	26.72	1.60	40	Kohala
9	....	15.8	15.8	15.8	15.8	....	....	....	...	288	290	293	347	...	...	...	24.65	1.44	9	Waianae
1	....	15.5	15.5	15	....	....	....	....	...	...	260	...	...	...	...	...	17.65	1.74	1	Waimanalo
29	18	15.3	13.1	....	....	....	....	....	153	153	194	...	...	...	...	...	12.22	1.18	29	Halawa
4	....	13.6	14.1	13.6	17	....	....	....	...	215	...	154	154	...	...	...	15.50	1.52	4	Waimea
44	....	....	....	....	....	....	....	....	...	...	...	...	...	...	...	...	10.32	1.99	44	Kipahulu

* … mill opening 1/2x0, 7th mill opening 1/16x0. Returner bar clearance center, 6th mill 1 1/2, 7th mill 1 3/8.

† … mill opening 3/4x0, 7th mill opening 3/8x0. Returner bar clearance 6th mill 1 1/2, 1 3/4, 2; 7th mill 1 1/2, 1 3/4, 2.

TABLE NO. 1.

VARIETIES OF CANE.

	Lahaina	Yellow Caledonia	D 1135	Striped and Yellow Tip	Rose Bamboo	D 117	H 109	Other Varieties
H. C. & S. Co.	89	...	9	..	..	..	2	..
Maui Agr.	72	...	26	..	1	..	1	..
Oahu	74	9	8	..	..	..	4	5
Ewa	16	28	2	..	..	..	43	11
Pioneer	94	...	..	..	..	..	..	6
Waialua	51	11	15	..	2	6	5	10
Haw. Sug.	87	1	9	..	..	..	3	..
Olaa	..	92	8	..	..	..	..	..
Honolulu	55	39	5	..	..	..	..	1
Onomea	..	88	..	12	..	..	..	..
Hakalau	..	100	..	..	..	..	..	..
Kekaha	85	...	13	..	..	..	..	2
Hilo	..	96	3	1	..	..	..	..
Wailuku	50	2	25	..	..	..	2	21*
McBryde	4	60	32	..	..	..	3	1
Honokaa	..	65	11	24	..	..	..	..
Waiakea	..	100	..	..	..	..	..	..
Hawn. Agr.	..	61	..	..	7	..	..	32†
Lihue	..	97	3	..	..	..	..	..
Lihue, Han.	..	100	..	..	..	..	..	..
Laupahoehoe	..	50	11	17	..	14	..	8
Makee	..	98	..	..	..	..	..	2
Pepeekeo	..	95	..	2	3	..	..	..
Paauhau	..	88	4	8	..	..	..	..
Kahuku	28	65	6	..	..	..	1	..
Hawi	..	89	..	11	..	..	..	..
Honomu	..	100	..	..	..	..	..	..
Koloa	12	85	2	..	..	..	..	1
Hutchinson	..	8	..	..	87	..	..	5
Kaiwiki	..	75	..	5	..	10	..	10
Kaeleku	..	100	..	..	..	..	..	..
Kilauea	..	100	..	..	..	..	..	..
Kohala	..	55	15	30	..	..	..	..
Waianae	91	2	1	..	..	..	5	1
Waimanalo	..	98	..	..	2	..	..	..
Halawa	..	60	10	30	..	..	..	..
Waimea	98	...	2	..	..	..	..	..
Kipahulu	..	100	..	..	..	..	..	..
Average	37.9	42.9	7.5	2.0	1.1	0.8	4.0	3.8

* Striped Mexican 19%
† Yellow Bamboo 25%.

Compositions of Cane, by Islands.

The cane was the poorest in quality of any season since this report has been published. The same statement will apply also to every island, and to nearly every plantation. On 34 of the 38 plantations reporting, the polarization of the cane was lower than last season and more tons of cane were required to make a ton of sugar.

TABLE NO. 2.

COMPOSITION OF CANE BY ISLANDS.

	Hawaii	Maui	Oahu	Kauai	Whole Group
1909					
Polarization	13.54	15.67	15.06	14.43	14.79
Percent Fiber	12.26	11.20	12.80	12.49	12.12
Purity 1st Mill Juice.	88.76	92.02	90.55	88.43	90.00
1910					
Polarization	13.53	15.90	14.54	14.00	14.47
Percent Fiber	12.91	11.19	12.75	13.12	12.39
Purity 1st Mill Juice.	88.52	91.60	88.12	88.25	88.90
1911					
Polarization	12.91	15.45	14.45	13.51	13.99
Percent Fiber	13.27	11.79	12.92	13.26	12.85
Purity 1st Mill Juice.	88.15	91.57	88.20	87.46	88.83
1912					
Polarization	13.30	16.00	14.28	14.06	14.34
Percent Fiber	13.53	11.53	12.62	12.59	12.67
Purity 1st Mill Juice.	88.40	91.13	88.46	88.30	89.04
1913					
Polarization	13.22	15.56	14.21	13.70	14.05
Percent Fiber	13.74	11.73	12.75	12.50	12.85
Purity 1st Mill Juice.	88.47	91.11	88.20	88.12	89.02
1914					
Polarization	12.75	15.16	14.23	13.62	13.78
Persent Fiber	13.62	11.59	12.44	12.75	12.74
Purity 1st Mill Juice.	88.22	91.02	88.11	87.51	88.71
1915					
Polarization	12.61	15.23	14.29	14.09	13.77
Percent Fiber	13.00	11.44	12.77	12.46	12.51
Purity 1st Mill Juice.	87.86	90.48	87.27	86.99	88.24
1916					
Polarization	12.54	14.62	13.74	13.26	13.45
Percent Fiber	13.22	12.22	12.51	12.86	12.74
Purity 1st Mill Juice.	87.56	89.41	87.15	86.26	87.70
1917					
Polarization	13.31	15.43	13.55	13.13	13.76
Percent Fiber	13.23	11.67	12.25	12.89	12.62
Purity 1st Mill Juice.	88.11	90.69	86.86	86.70	88.02
1918					
Polarization	11.88	14.25	13.50	12.54	12.97
Percent Fiber	13.35	11.53	12.23	12.84	12.50
Purity 1st Mill Juice.	87.27	88.62	86.93	85.88	87.18

Milling.

Although there were but few changes in the milling machinery employed, there was an improvement in results, shown by a decrease in the average milling loss and extraction ratio and an increase in extraction. In spite of the poorer quality of the cane, therefore, a larger proportion of the sugar was obtained from it, by an increased efficiency in the milling.

TABLE NO. 3.—MILLING RESULTS.

Showing the Rank of the Different Plantations on the Basis of Milling Loss.

Factory	Milling Loss	Extraction Ratio	Extraction	Equipment
1. Maui Agr....	1.44	0.10	98.89	K(2),21RM
2. Onomea.....	1.48	0.13	98.40	2RC,S,12RM
3. Waimea.....	1.80	0.14	98.43	2RC,12RM
4. Hakalau.....	1.84	0.15	98.03	2RC,12RM
5. Ewa.........	1.87	0.15	98.20	K(2),20RM
6. Hilo.........	1.91	0.15	97.90	K,2RC,12RM
7. H. C. & S. Co..	2.13	0.14	98.47	K(4),2RC(2),S(2),12RM(2)
8. Wailuku.....	2.38	0.19	97.56	K,2RC,12RM
9. McBryde....	2.42	0.20	97.54	K,S,9RM
10. Paauhau.....	2.42	0.22	96.79	2RC,12RM
11. Kilauea.....	2.59	0.24	97.02	K,S,3RC,9RM
12. Koloa.......	2.64	0.22	96.95	K,2RC,12RM
13. Waianae.....	2.74	0.19	97.56	12RM
14. Pepeekeo....	2.79	0.22	97.05	2RC,9RM
15. Haw. Sug....	2.84	0.21	97.40	K,2RC,S,12RM
16. Waialua.....	2.88	0.21	97.30	K2,14RM
17. Olaa.........	2.91	0.25	96.60	K,S,12RM
18. Lihue.......	2.93	0.24	96.51	K,2RC,12RM
19. Kahuku.....	2.94	0.25	96.63	3RC,S,9RM
20. Honomu.....	3.07	0.25	96.70	2RC,9RM
21. Honolulu....	3.10	0.22	97.26	K(2),S,11RM
22. Haw. Agr....	3.22	0.27	96.30	3RC,12RM
23. Pioneer......	3.34	0.23	97.22	K,2RC,S,12RM
24. Honokaa....	3.41	0.34	95.20	K(2),2RC,12RM
25. Kekaha.....	3.54	0.27	96.64	2RC,9RM
26. Oahu.........	3.59	0.25	97.13	K(4),S,14RM—12RM
27. Lihue, Han..	3.63	0.28	96.13	K, 2RC,9RM
28. Laupahoehoe.	3.97	0.33	95.68	K(2),2RC,9RM
29. Kaeleku.....	4.03	0.36	94.95	K(2),2RC,9RM
30. Makee.......	4.04	0.38	95.61	K(2),9RM
31. Hutchinson..	4.08	0.37	95.24	2RC,9RM
32. Kohala......	4.36	0.37	95.14	K(2),S,11RM
33. Waiakea....	4.45	0.35	95.65	K,S,11RM
34. Hawi.......	4.54	0.36	95.28	K(3),3RC,12RM—S,9RM
35. Kaiwiki.....	4.74	0.37	95.29	K(2),2RC,9RM
36. Halawa......	7.53	0.67	90.41	K,2RC,6RM
37. Kipahulu....	10.31	0.82	88.23	K,5RM

Comparing the above table with that of last season shows the improvement that has been made in milling.

Milling Loss	No. of Factories	
	In 1917	In 1918
Under 2.0	3	6
" 3.0	15	19
" 4.0	25	28
Over 5.0	7	2

The mill of the Maui Agricultural Company established a new record in Milling Loss, Extraction Ratio and Extraction. During the season, also, this mill obtained an extraction of over 99% for seventeen consecutive weeks.

Other mills which have made a noticeable improvement in their standing in the above table are Ewa, McBryde and Koloa. Waimea appears for the first time in the table, near the top.

Clarification.

There was considerable improvement in the average increase in purity. The reliability of this figure is somewhat disturbed on account of a few factories still returning remelted sugar to the juice, the purity of the syrup being raised or lowered in this way, depending on the quality of the sugar that is remelted.

Filter Pressing.

The average figures for the press-cake continued to follow in the direction in which they have been going the last few years, showing an increase in weight of cake but decrease in polarization. The loss in sugar in proportion to that in the cane was practically the same as last season.

Evaporation.

There was a further decrease in the Brix of the syrup this season. The lower density of the cane juice was responsible for part of this, as the percentage evaporation was slightly greater this season than last, which would indicate that, as a rule, the factories are working up to the capacity of their evaporators, and are not able to handle any surplus. Another cause for the lower density of the syrup may be that referred to in last season's

report, namely, its intentional reduction by the sugar boiler for the purpose of aiding the boiling of a large-grained sugar. This cause will only be temporary. After the pan-men have had more experience in boiling larger-grained sugar they should be able to handle heavy syrup again.

The evaporation of the syrup to a high density is a matter of especial importance to those factories that are burning extra fuel, of which there are quite a number. Considerably more steam is required to evaporate at single effect in the vacuum pan than at quadruple effect in the evaporator, and the latter should therefore be carried to the limit. It is poor economy to fail to provide ample evaporator capacity and continue to burn extra fuel.

Commercial Sugar.

The composition of the commercial sugar showed a marked change in 1917, but returned this season to more nearly normal. There are several factories, however, still making sugar of unnecessarily high polarization.

Final Molasses.

Previous to 1917 there had been a gradual drop each season in the average purity of the final molasses. Last season the purity went up, on account of the disorganization in methods of sugar boiling in the efforts that were then being made to improve the refining quality of the commercial sugars. It was predicted, however, in last season's report that this would be only temporary. And such it has proven to be, the average purity this season showing a very gratifying decrease of nearly one per cent over that of last season and the lowest average purity that has yet been obtained.

It will be interesting to calculate what this means in additional recovery of sugar. Calculating from the average apparent purities this season of the syrup and the sugar, the gravity purities to be 86.6 and 97.7 respectively, then on the basis of 40.03 gravity purity of the molasses (which it was last season) and 39.07 gravity purity, there would be recoveries of 91.11 and 91.47 per cent sucrose respectively.

The drop in purity of the molasses has therefore increased this year's crop of sugar by about 2300 tons. At an average valuation of $90 a ton on the plantation, the increased returns from the extra sugar recovered amount to $200,000.

Boiling-house Recoveries and Balances.

With the same quality of work as last season in the boiling-houses, the recovery would have been much less this season on account of the large drop in the average purity of the juice. The mixed juice was 0.9% lower in purity and the syrup 0.6% lower. But on account of the lower purity of the molasses, the apparent boiling-house recovery showed a drop of only 0.2 of a per cent.

TABLE NO 4.
GRAVITY SOLIDS AND SUCROSE BALANCES.

Factory	Gravity solids per 100 gravity solids in mixed juice				Sucrose per 100 sucrose in mixed juice			
	Press Cake	Commercial Sugar	Final Molasses	Undetermined	Press Cake	Commercial Sugar	Final Molasses	Undetermined
Maui Agr.	4.1	77.3	17.5	1.1	0.4	90.9	8.6	0.1
Oahu	4.8	79.6	13.2	2.4	0.3	92.7	6.2	0.8
Pioneer	3.2	78.8	15.6	2.4	0.3	91.4	7.1	1.2
Waialua	4.0	76.7	17.5	1.8	0.2	90.2	8.3	1.3
Onomea	5.8	78.8	14.1	1.3	0.1	93.4	6.0	0.5
Hakalau	5.4	76.4	14.5	3.7	0.2	91.5	6.8	1.5
Hilo	4.6	79.1	14.7	1.6	0.2	92.7	6.5	0.6
Wailuku	4.6	76.9	16.1	2.4	0.3	90.6	7.7	1.4
Honokaa	6.1	66.9	26.1	0.9	0.5	85.1	13.2	1.2
Haw. Agr.	3.9	77.1	19.0	0.0	0.1	89.3	9.1	1.5
Pepeekeo	5.3	79.5	14.9	0.3	0.2	91.6	6.8	1.4
Paauhau	6.6	73.5	18.9	1.0	0.6	89.4	9.0	1.0
Honomu	5.5	78.5	13.9	2.1	0.2	92.6	6.0	1.2
Hutchinson	2.4	76.2	17.3	4.1	0.1	88.3	8.4	3.2
Kilauea	4.8	68.9	24.8	1.5	0.6	85.2	12.5	1.7

TABLE NO. 5.

APPARENT BOILING HOUSE RECOVERY.

Comparing percent. available sucrose (calculated by formula) with percent. polarization actually obtained.

Factory	Available*	Obtained	Recovery on Available
H. C. & S. Co....	92.94	91.48	98.4
Maui Agr.	90.47	91.16 †	100.8
Oahu	92.59	93.44	100.9
Ewa	89.57	89.31	99.7
Pioneer	91.88	91.98	100.1
Waialua	91.44	90.64	99.1
Haw. Sug.	91.24	91.25	100.0
Olaa	92.18	90.71	98.4
Onomea	93.39	93.84	100.5
Hakalau	91.27	91.58	100.3
Kekaha	91.82	90.73	98.8
Hilo	93.17	92.66	99.5
Wailuku	91.17	91.48	100.3
McBryde	89.12	87.33	98.0
Honokaa	87.24	85.66	98.2
Waiakea	90.85	88.65	97.6
Haw. Agr.	92.06	89.52	97.2
Lihue	89.36	89.33	100.0
Lihue, Han.	91.42	89.43	97.8
Laupahoehoe . .	91.88	92.60	100.8
Makee	89.11	91.81	103.0
Pepeekeo	94.12	91.99	97.7
Paauhau	90.92	90.07	99.1
Kahuku	88.48	87.90	99.3
Hawi	91.21	85.09	93.3
Honomu	93.31	93.28	100.0
Koloa	89.05	88.17	99.0
Hutchinson	90.27	88.83	98.4
Kaiwiki	89.76	90.49	100.8
Kaeleku	90.43	89.60	99.1
Kilauea	87.14	86.59	99.4
Kohala	91.40	91.33	99.9
Waianae	90.84	86.59	95.3
Halawa	91.10	74.70	82.0
Waimea	91.40	86.78	94.9
Kipahulu	93.01	85.30	91.7

* For the purpose of calculating the available sucrose figures in this column an arbitrary method for finding the gravity purity of the syrup and commercial sugar has been used. It has been assumed that the gravity purity of the syrup is 0.8 higher than the apparent purity and that of the sugar 0.4 higher than the purity calculated from the polarization and total solids. Comparison of the figures so obtained with the actual gravity purities as determined, for several seasons, shows that the calculation is reliable, on an average, as applied to the syrup, but that a factor of 0.3 should be used for the sugar instead of 0.4. A factor of 0.3 has been used this season, and the moisture in the sugar and gravity purity of the final molasses, when not given, have been assumed to be 1% and 38% respectively, as heretofore.

† Sucrose, not polarization.

TABLE NO 6.

TRUE BOILING HOUSE RECOVERY.

Comparing percent. sucrose, available and recovered.

Factory	Available	Obtained	Percent Recovery on Available
Maui Agr.	90.47	91.27	100.9
Oahu	92.52	92.98	100.5
Pioneer	91.86	91.68	99.8
Waialua	91.08	90.38	99.2
Onomea	93.47	93.49	100.0
Hakalau	91.29	91.68	100.4
Hilo	92.81	92.89	100.1
Wailuku	91.26	90.87	99.6
Honokaa	86.76	85.53	98.6
Haw. Agr.	91.93	89.39	97.2
Pepeekeo	93.88	91.78	97.8
Paauhau	90.90	89.94	98.9
Honomu	93.25	92.79	99.5
Hutchinson	90.44	88.39	97.7
Kaiwiki	89.70	89.26	99.5
Kilauea	87.27	85.71	98.2

In the 1915 report it was stated, in regard to the figures in the last columns of Tables 5 and 6, that "the results reported by those factories showing over 101% recovery are very probably in error." Further experience in comparing the figures from the different factories each year makes it seem quite probable that an even closer limit could be drawn with fairness, especially in connection with the figures based on true sucrose in Table 6. There would seem to be no good reason why the calculated results in the last column of this table should run over 100.0 per cent.

Factory Efficiency.

Notwithstanding the lower purity of the juices, which makes their sugar content less available, the percentage recovery of the sugar in the cane was practically the same as for the previous year. This was due to the increased efficiency, this season, in the factory work as a whole.

TABLE NO. 7.

FACTORY EFFICIENCY.

Showing the comparative standing of the plantations on the basis of the entire factory work.

No.	Factory	TOTAL RECOVERY		Factory Efficiency
		Calculated	Obtained	
1	Onomea	94.53	92.26	97.60
2	Maui Agr.	94.01	89.81	95.53
3	Hakalau	93.84	89.64	95.52
4	Hilo	94.83	90.53	95.47
5	Oahu	94.82	90.46	95.40
6	Honomu	94.58	89.99	95.15
7	Ewa	92.39	87.49	94.70
8	Pioneer	94.24	89.18	94.63
9	Wailuku	94.07	88.99	94.60
10	H. C. & S. Co.	95.43	89.98	94.29
11	Haw. Sug.	94.37	88.69	93.98
12	Waialua	94.25	87.99	93.36
13	Lihue	92.11	85.93	93.29
14	Pepeekeo	95.82	89.08	92.97
15	Laupahoehoe	95.17	88.47	92.96
16	Paauhau	93.40	86.62	92.74
17	Olaa	94.28	87.32	92.62
18	Kohala	93.65	86.71	92.59
19	Kekaha	94.33	87.19	92.43
20	Koloa	92.22	85.18	92.37
21	Kahuku	91.54	84.45	92.25
22	McBryde	92.73	85.09	91.76
23	Kaiwiki	93.76	85.90	91.62
24	Kilauea	91.44	83.54	91.36
25	Kaeleku	93.06	84.78	91.10
26	Haw. Agr.	94.82	86.15	90.86
27	Waimea	93.90	85.27	90.81
28	Lihue, Han	94.27	85.58	90.78
29	Hutchinson	93.53	84.49	90.33
30	Waianae	93.77	84.24	89.84
31	Waiakea	94.40	84.54	89.56
32	Honokaa	91.11	81.12	89.04
33	Hawi	93.66	80.73	86.19
34	Kipahulu	94.74	74.50	78.64
35	Halawa	93.25	67.46	72.34

The factory efficiency has previously been calculated on the basis of 100 per cent extraction at the mill and a gravity purity of 35 in the final molasses. Some factories have already obtained molasses of lower purity than this, so it can no longer be considered as a lower limit. The first column in the above table has been calculated on the basis of 100 per cent extraction at the mill and 30 gravity purity molasses. The factory efficiency figures are therefore not comparable with those of former years.

Losses in Manufacture.

Of the three sources of manufacturing loss, bagasse, press cake, and molasses, we would expect the former, in a general way, to decrease with increase in size of the plantation. For the press cake there is no reason why it should be much different on one plantation than another. The percentage loss in molasses, with equally good work in the boiling-house, will necessarily vary considerably with the purities of the juices.

The order in which the factories are listed in the tables this season gives a better opportunity for noting, in Table 8, whether the loss in bagasse in any particular factory is greater or less than on other plantations of similar size.

There was an increased loss in molasses, due entirely to the lower purity of the juice, and therefore unpreventable by the factory. Its problem is to keep the loss as low as possible for the juice with which it is furnished. This can be done only by reducing the purity of the final molasses. The notable improvement that was made in this direction this season has already been commented upon. There is ample room for still further improvement, and, as this is now our most important loss, it calls for increased attention in the factories.

The calculations and tabulations involved in preparation of this report, as in previous recent reports, have been made mainly by Mr. McAllep.

TABLE NO. 8.
SUMMARY OF LOSSES.

FACTORY	Pounds Polarization per Ton of Cane: Bagasse	Press Cake	Molasses	Undetermined	TOTAL	Per 100 Cane: Bagasse	Press Cake	Molasses	Undetermined	TOTAL	Per 100 Polarization of Cane: Bagasse	Press Cake	Molasses	Undetermined	TOTAL	Syrup Purity	FACTORY
H. C. & S. Co.	4.6	0.4	20.8	4.2	30.0	0.23	0.02	1.04	0.21	1.50	1.53	0.12	6.96	1.41	10.02	88.11	H. C. & S. Co.
Maui Agr.	3.2	1.0	24.6	0.6	29.4	0.16	0.05	1.23	0.03	1.47	1.11	0.37	8.52	0.19	10.19	86.34	Maui Agr.
Oahu	8.0	0.8	17.0	0.8	26.6	0.40	0.04	0.85	0.04	1.33	2.87	0.32	6.04	0.31	9.54	87.05	Oahu.
Ewa	4.4	0.6	23.8	2.2	31.0	0.22	0.03	1.19	0.11	1.55	1.80	0.24	9.57	0.90	12.51	83.05	Ewa.
Pioneer	8.0	0.8	20.0	2.2	31.0	0.40	0.04	1.00	0.11	1.55	2.78	0.26	6.97	0.80	10.81	86.20	Pioneer.
Waialua	7.4	0.6	22.4	2.6	33.0	0.37	0.03	1.12	0.13	1.65	2.70	0.22	8.13	0.96	12.01	86.2	Waialua.
Haw. Sug.	7.2	0.6	22.0	1.6	31.4	0.36	0.03	1.10	0.08	1.57	2.60	0.21	7.92	0.58	11.31	86.03	Haw. Sug.
Olaa	7.8	0.8	19.2	1.4	29.2	0.39	0.04	0.96	0.07	1.46	3.40	0.34	8.33	0.61	12.68	86.5	Olaa.
Honolulu	7.8	0.4	....	....	....	0.39	0.02	....	....	....	2.74	0.13	.....	....	.....	87.90	Honolulu.
Onomea	3.8	0.2	14.0	0.2	18.2	0.19	0.01	0.70	0.01	0.91	1.60	0.09	5.94	0.11	7.74	86.3	Onomea.
Hakalau	5.0	0.4	16.6	3.8	25.8	0.25	0.02	0.83	0.19	1.29	1.97	0.15	6.70	1.54	10.36	85.3	Hakalau.
Kekaha	8.8	1.4	21.6	1.6	33.4	0.44	0.07	1.08	0.08	1.67	3.36	0.55	8.28	0.62	12.81	86.24	Kekaha.
Hilo	5.4	0.4	15.8	2.0	23.6	0.27	0.02	0.79	0.10	1.18	2.10	0.19	6.36	0.82	9.47	86.9	Hilo.
Wailuku	6.0	0.8	19.0	1.6	27.4	0.30	0.04	0.95	0.08	1.37	2.44	0.28	7.65	0.64	11.01	85.7	Wailuku.
McBryde	6.0	0.2	26.0	4.0	36.2	0.30	0.01	1.30	0.20	1.81	2.46	0.10	10.68	1.67	14.91	83.5	McBryde.
Honokaa	9.6	1.0	25.2	1.8	37.6	0.48	0.05	1.26	0.09	1.88	4.80	0.50	12.65	0.93	18.83	81.01	Honokaa.
Waiakea	11.2	0.8	26.2	1.4	39.6	0.56	0.04	1.31	0.07	1.98	4.35	0.29	10.27	0.55	15.46	86.43	Waiakea.
Haw. Agr.	8.8	0.2	21.2	2.8	33.0	0.44	0.01	1.06	0.14	1.65	3.70	0.06	8.89	1.20	13.85	86.92	Haw. Agr.
Lihue	8.6	0.8	24.2	0.8	34.4	0.43	0.04	1.21	0.04	1.72	3.49	0.32	9.91	0.35	14.07	82.7	Lihue.
Lihue, Han.	10.2	1.2	....	26.6	38.0	0.51	0.06	....	1.33	1.90	3.87	0.43	.....	10.12	14.42	86.2	Lihue, Han.
Laupahoehoe	10.4	0.4	15.2	1.8	27.8	0.52	0.02	0.76	0.09	1.39	4.32	0.15	6.30	0.76	11.53	87.13	Laupahoehoe.
Makee	9.4	0.8	....	16.8	27.0*	0.47	0.04	....	0.84	1.35*	4.39	0.39	.....	7.80	12.58*	82.39	Makee.
Pepeekeo	7.4	0.6	16.6	2.8	27.4	0.37	0.03	0.83	0.14	1.37	2.95	0.22	6.63	1.13	10.93	88.57	Pepeekeo.
Paauhau	7.2	1.4	19.6	1.8	30.0	0.36	0.07	0.98	0.09	1.50	3.21	0.62	8.73	0.82	13.38	84.50	Paauhau.
Kahuku	8.0	1.2	25.0	2.6	36.8	0.40	0.06	1.25	0.13	1.84	3.37	0.55	10.54	1.09	15.55	81.75	Kahuku.
Hawi	12.0	1.0	....	36.0	49.0	0.60	0.05	....	1.80	2.45	4.72	0.41	.....	14.12	19.25	84.97	Hawi.
Honomu	8.2	0.6	14.6	1.6	25.0	0.41	0.03	0.73	0.08	1.25	3.30	0.22	5.84	0.65	10.01	86.7	Honomu.
Koloa	7.4	0.8	....	28.0	36.2	0.37	0.04	....	1.40	1.81	3.05	0.35	.....	11.44	14.84	82.6	Koloa.
Hutchinson	10.4	0.2	17.6	5.8	34.0	0.52	0.01	0.88	0.29	1.70	4.76	0.12	8.01	2.62	15.51	85.1	Hutchinson.
Kaiwiki	12.2	1.0	....	23.2	36.4	0.61	0.05	....	1.16	1.82	4.71	0.36	.....	9.03	14.10	84.99	Kaiwiki.
Kaeleku	11.4	0.8	....	22.2	34.4	0.57	0.04	....	1.11	1.72	5.05	0.34	.....	9.84	15.23	84.00	Kaeleku.
Kilauea	6.6	1.2	27.0	1.4	36.2	0.33	0.06	1.35	0.07	1.81	2.98	0.55	12.32	0.61	16.46	81.8	Kilauea.
Kohala	11.4	0.4	16.8	2.6	31.2	0.57	0.02	0.84	0.13	1.56	4.85	0.20	7.18	1.06	13.29	84.8	Kohala.
Waianae	7.0	0.8	....	36.8	44.6	0.35	0.04	....	1.84	2.23	2.44	0.28	.....	13.04	15.76	85.15	Waianae.
Halawa	21.6	0.2	....	51.6	73.4	1.08	0.01	....	2.58	3.67	9.59	0.10	.....	22.85	32.54	84.31	Halawa.
Waimea	4.0	0.6	....	33.4	38.0	0.20	0.03	....	1.67	1.90	1.57	0.17	.....	12.99	14.73	85.40	Waimea.
Kipahulu	29.6	2.2	....	32.4	64.2	1.48	0.11	....	1.62	3.21	11.77	0.89	.....	12.84	25.50	87.05	Kipahulu.

* A comparison of the available sucrose in the juice with the amount recovered in the boiling house indicates that there is probably an error in some of the results reported from this factory.